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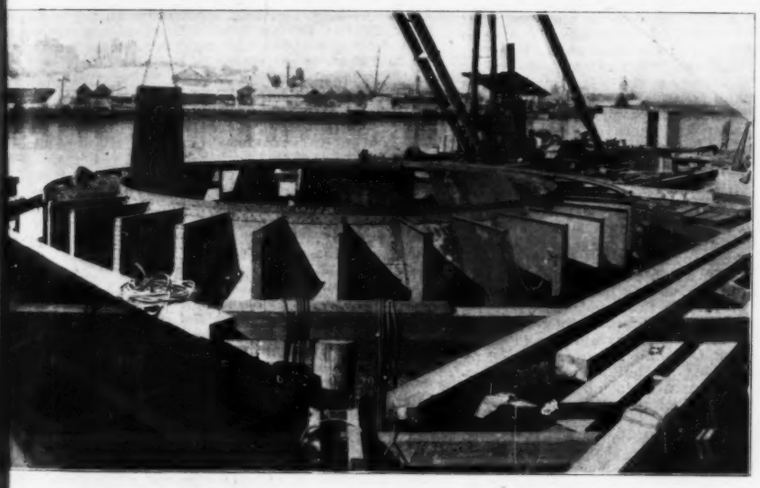
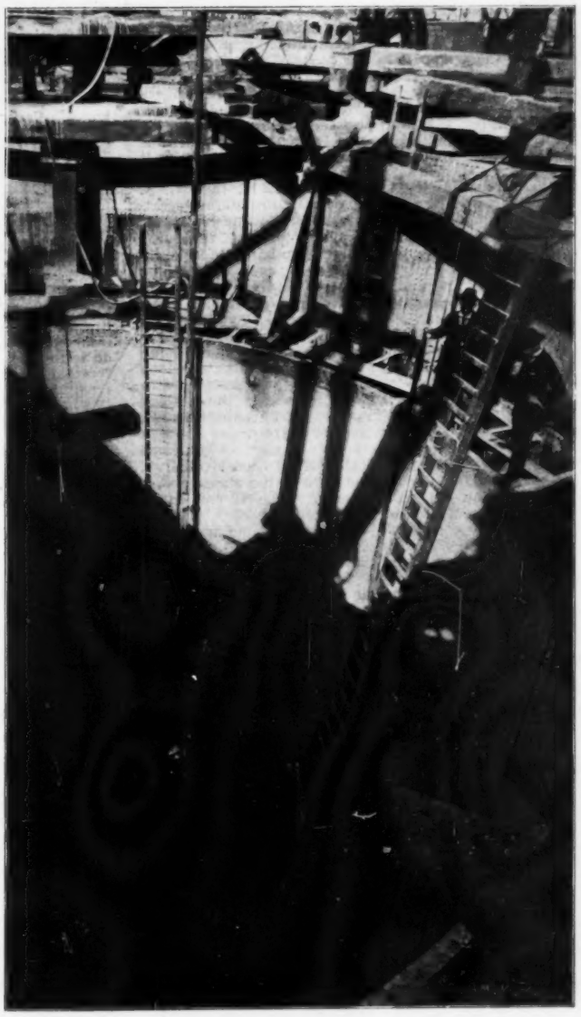
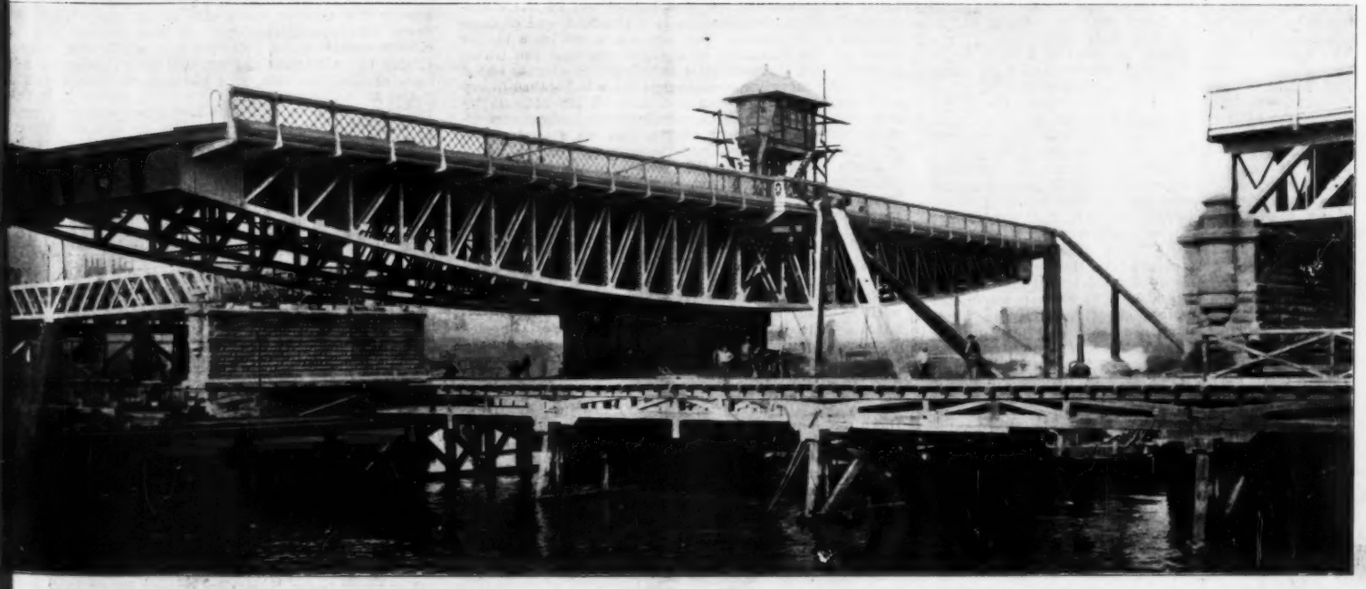
CLEANING THE ROCK BOTTOM, 60 FEET BELOW HIGH WATER MARK.



BOTTOM LENGTH OF CAISSON BEFORE LOWERING INTO THE WATER.



VIEW FROM TOP OF CAISSON AFTER PUMPING OUT.



VIEW SHOWING THE SWING SPAN OPEN.

THE NEW PYRMONT BRIDGE, SYDNEY, NEW SOUTH WALES.

PYRMONT BRIDGE, SYDNEY, AUSTRALIA.*

By JOHN PLUMMER.

DARLING HARBOR, one of the many arms of Port Jackson, divides the New South Wales metropolis into a couple of large but somewhat unequal portions, communication between the two opposite shores being conducted by small ferryboats until 1857, when a wooden bridge, constructed by private enterprise at a cost of $375,000 was opened, a small toll being levied on each passenger, animal, or vehicle crossing. The piles were of Australian hardwood and have remained perfectly sound to the present day, but the upper portions of the structure, being of softer timber, have repeatedly suffered from the attacks of white ants. There was a swing span in the center to enable masted vessels to pass through, but the lowness of the bridge proved such a barrier otherwise, even to the smallest steamboat, that the stream of business traffic, very heavy during certain portions of the day, was continually being interrupted to allow the swing span, worked by mechanical power, with the assistance of a couple of men, being used.

In 1884 the bridge was purchased for the sum of $200,000 by the state government, and the tolls abolished, with the result that the passenger and vehicular traffic expanded so rapidly that a new bridge became indispensable. After various preliminaries, competitive designs were invited from America and Europe, that obtaining the first premium being estimated to involve an expenditure of $1,478,500. This cost was regarded as somewhat expensive, and ultimately it was arranged that a bridge should be constructed from designs prepared by Mr. Percy Allan, M. Inst. C. E. (England), one of the engineers in the state Department of Public Works, and an Australian by birth.

It was arranged that with the exception of the swing span, 223 feet in length, Australian hardwood should be the principal material employed, each of the side spans, twelve in number, having a length of 82 feet, the roadway supported by them being of asphalt. The heaviest portion of the undertaking was in connection with the construction and sinking of the caisson forming the main support of the swing span. There being no iron works on a large scale in Australia, the iron work comprising the caisson had to be constructed in Europe, and shipped to Sydney, where the cutting edge was placed in position on a square ironbark frame, suspended above high water by wire ropes from a staging surrounding the site of the pier. After some 15 feet of the sides of the caisson had been riveted up, the wire ropes at the four corners of the staging were eased, and the immense chamber, some 42 feet in diameter, lowered into the water, until, with a draft of 7 feet 3 inches, it floated when the frame was withdrawn.

Additional plates were added, and the caisson gradually sank in the water by filling with concrete the space between the inner and outer rings. The work of grounding the cylinder, by means of girders and wedges, in the position it was destined to permanently occupy, proved a source of considerable anxiety to all concerned, but by judicious handling, it was placed with such nice accuracy, that the work of dredging the interior could be commenced without delay, by means of a bucket dredge, as the plates were built up and concrete weighting added. This process was continued until a depth of 46 feet under low-water mark was reached, at which point the cutting edge touched rock on one side. The task of pumping out the water was begun, and as the quantity became reduced, it was found that there was very little leakage under the cutting edge.

Subsequently a start was made with cutting the rock on the side where it was highest, and while this was being done a sudden influx of water, filling the interior of the cylinder, endangered the lives of the men employed. Fortunately, they escaped without serious injury, the last man just keeping his head above water as he rushed up the ladder. To prevent a reoccurrence of an inflow, a bank of clay was built around the caisson, and the remainder of the work of excavation effected under water by means of a large cast-steel jumper, also one of smaller size. When the contract depth had been reached, bags of concrete were placed by divers around the bottom of the interior sides, and these, backed by a ring of concrete, deposited through 60 feet of water. When these operations were completed, the water was pumped out, the interior of the caisson being found perfectly water-tight.

The upper space between the outer and inner walls of iron plate was fitted with heavy blocks of stone imbedded in concrete, up to low-water mark, when masonry took the place of the iron work, the whole forming one of the strongest and most durable structures imaginable, the solid mass of stone and concrete alone representing a dead weight of over 6,800 tons.

Electricity supplies the motive power for working the swing span, the American principle being adopted throughout. Both the slewing and lift motors are carried on a platform inside the cylinder, the former working through a train of gears a vertical shaft, on the lower end of which is a cast-steel pinion meshing with a cast-steel rack secured to the top of a pivot pier; while the end lift is effected by means of cones on horizontal shafts worked by a 35 horse power motor gearing onto a longitudinal shaft running the whole length of the swing span.

The estimated cost of the structure, which possesses a substantial yet somewhat graceful appearance, is $560,000, against $1,478,500, that of the design obtaining the first premium in the competition open to the world; also the necessary works were on a more extended scale, by reason of improved approaches having to be made.

Wheat Prospects in Russia.—Consul-General W. R. Holloway writes from St. Petersburg, May 15, 1903, that, according to data compiled by the Ministry of Agriculture, the outlook for wheat in European Russia is satisfactory. Winter wheat is fair, especially in the southern provinces. The spring has been unusually mild.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

SOME LIMITS IN HEAVY ELECTRICAL ENGINEERING.*

IT is customary for a presidential address to be a review of the development of the science with which the Institution is particularly concerned. Such a review is especially beneficial in the case of such a rapidly growing industry as electrical engineering, as the outlook changes considerably during a year. Instead of a review of the past, a dream of the future may take the form of a presidential address. This form has great attractions for me for several reasons. In the first place, this kind of prophecy is easy and pleasant. I might draw a rosy picture of a future when everything conceivable is done electrically. We shall have electrical energy developed direct from carbon at the coal-pits. Not only all our lighting, but all our domestic heating will be done electrically. There will be no smoke in our cities or in what will correspond to them. Most of the dirt of our houses will have vanished. Large and crowded towns will have disappeared, because the telegraph will have given way to its wireless rival, and that will have given way to the wireless telephone with no exchanges and no subscriptions. There will thus be no need for people to go and see one another to transact business. Even when matters must be written to preserve a record, no office will be necessary. You will dictate by wireless telephony to your shorthand clerk at his distant house. Perhaps we shall all learn shorthand instead of our present cumbersome system of writing, and all books and letters will be in one language, written and printed phonetically at speaking speed or faster. The horse will have gone, leaving clean and odorless streets, with smooth surfaces on which people will travel in rapid electric automobiles. The railways with very rapid long-distance service will be entirely electric. It is very easy to prophesy in this sort of way, not only in a general way, but in considerable detail; and it is an amusement that brings much credit to the prophet. If any of his prophecies seem unlikely to come true, he merely has to say, "Wait a little!" While if anything like what he foretells comes into existence, say twenty years hence, all he has to do is to refer back to an address to claim that he has foretold it, and the future inventor will have half his credit taken from him and given to the prophet. If the prophecies are sufficiently vague, there is certain to be some sort of fulfillment of some of them sooner or later, and it is always well to have a good many past publications of this sort in stock waiting for future development.

Great though the temptation is, I will resist it, and try to look into the future from quite a different point of view. We have been going ahead so very fast lately—even our acceleration itself increasing—that we may be a little apt to have vague views of what we can and what we cannot do electrically. It may be well, therefore, to try to look over some of the branches of our great and diverse industry, and see what obstacles are now opposing us and what are likely to oppose us shortly, and whether the obstacles are insuperable or not. This sort of prophecy is much more difficult than the other, for there can be no credit twenty years hence in having said something could not be done, even if it has not, while if it has been accomplished the position is still more difficult. Negative prophecy is thus unattractive. But the discussion of our limits may not only have a beneficial effect in making us modest, but it may be a much greater benefit if, by focusing our attention on a limit of any development, we find either that the obstacle is theoretically insurmountable, in which case we must go round it, or that it has to be scaled in a particular way.

There are clearly at least two kinds of obstacles. For instance, it is obviously impossible to get more than 746 watts out of a dynamo taking one horse power to drive it. But the limit of possible speed on an electric railway belongs to quite a different category. I will therefore discuss various branches of electrical technology, to see what may prevent or is preventing further advance.

Twenty years ago, this Institution was chiefly concerned with the development of the telegraph. We can get but few telegraph papers now. This is not because telegraphy is dead; it is because most of its problems are solved, so there is little to discuss. The fact that there is little to discuss in telegraphy is the proof of its vitality. It has passed out of the childhood of technical difficulties into the manhood of commercial development. Ten years ago, we were in the thick of the evolution of the dynamo and the transformer. But there is little but detail to discuss about electrical generating machinery. This is because heavy electrical machinery has got through its difficult infancy and is now a trade, which is the highest compliment that can be paid to it. But we electrical engineers have also developed through our difficult training into being the scientific branch of the engineering profession. Our exactness of calculation and measurement has leavened the steam engineers and the other manufacturers with whom we have to work in concert.

No one man can be a complete electrical engineer; but each of us ought to know one subject well and a large number of allied subjects fairly well. As a basis of technical knowledge which I am alone dealing with to-night, we must have a fairly all-round knowledge of "theoretical" physics and chemistry. Physics is merely unapplied engineering. Science is split—unfortunately, the split is very difficult to heal—into two parts, generally wrongly called the theory and the practice; or pure and applied science. This fissure is not so deep in our branch of engineering, but it is there. Science, to be worthy of the name, is knowledge of Nature utilized by man. Engineering is science, and science is engineering. You can cut off a part and call it unapplied science. This is what is generally known as theory or pure science. It is not purer than any other science, and the term theory is misapplied. To be an engineer you must know both branches. There is nothing superior about knowledge which is not yet applied. It is mere raw material; it may be useful when worked up, and it is valuable before it is worked up, but only because it may be worked up. The so-called practical man who works at applications without understanding the generalized principle is ignorant. He only understands a part of science. The so-called scientific man who only understands what is called pure science is just as ignorant. Each understands part of his subject only.

We as electrical engineers ought especially to help the split between the halves of science; a split which is much deeper in other branches of engineering, such as chemical and purely mechanical. We ought to unify knowledge of both branches of science in one individual as much as possible.

TIDES.

The tides are often referred to as a possible source of energy even to this day; and it is urged that in places where the tide rises abnormally, for instance in the estuary of the Severn, it would pay to make a dam with turbines. The sort of argument is that if you have an area of, say, 1,000 square meters and a total rise of 15 meters, you have 15,000 cubic meters of water, and as this runs in twice and out twice a day you have 15,000 cubic meters of water, falling the equivalent of 60 meters a day, or approximately 10 kilowatts. This statement contains many fallacies. In the first place, in order to get the full advantage of the difference of level, the water must be let in and out at high and low tide only. Even then the equivalent or average head during discharge or charge is only 7½ meters. But a system which gave an enormous power for a very short time four times a day would be of no use. The plant would be expensive and the result of no value. With a single tank it is impossible to get a continuous output. If the tide is coming in and you get the power by letting the tide fill the tank, the power will decrease to zero as the tide begins to fall and comes to the same level as the water in the tank. It is therefore necessary to have more than one tank. To make the plant practical, you want fairly constant pressure available on the turbines though you may waste head by sluices or valves. It is often said that a Norwegian fiord or a Scotch loch could be easily dammed and utilized, but it would be impossible to find three lochs all opening out together. The need for more than one reservoir does not seem to have been recognized. In addition, the demand for electrical energy on Scotch lochs or Norwegian fiords is rather minute.

WATER POWER.

Some years ago there was a great deal of excitement about the development of water powers. The possibility of "harnessing Niagara" and utilizing waterfalls all over the world was hailed as a great triumph over Nature, and the idea was that power could be got for nothing, and industries would all migrate from coal districts to the neighborhood of water power. The daily press and the magazines took the matter up, and there is something in the idea of saving some of the colossal waste of natural energy that appeals especially to the half-scientific or unpractical reader. At the time of the excitement, it was pointed out largely in vain, that water power did not cost nothing because the development of a fall demanded a good deal of capital, on which interest and depreciation had to be paid. But further than this, Ricardo's theory of rent is applicable to water powers as well as to arable land. If steam power costs a farthing per unit, and if water power at the same place can be produced for half a farthing, after paying working expenses and interest, the owner of the water power will claim the odd half farthing as rent, or will just allow the water power enough to encourage the production of a new thing. As a rule, however, a water power is not where it is wanted industrially. In the nature of things, water powers are generally in hilly countries and are seldom near the sea. The result is that a water power as a rule cannot command the same price as steam or gas, because it is not where it is wanted. The idea in starting many of the water-power stations also was that works which needed power would come and settle near. As a matter of fact, the cost of power is a much smaller item in most industries than is generally supposed, and it does not pay to start a works in an otherwise not perfectly suitable locality simply for the sake of the cheap water power. In such industries as engine building, flour milling, spinning and weaving, and so on, the chance of reducing the expense for power is not enough to overcome other considerations. It may be said that in electro-metallurgical processes the whole cost is practically the electrical energy, and so carbides, aluminium, electrolytic soda, and chlorate of potash will be made at water powers. Even this, however, is misleading. Carbides and aluminium are generally made at waterfalls, and chlorate nearly always is. Electrolytic soda and bleach are made at water powers, but are also made extensively by steam-driven plant. Against the cheaper power, we have to put extra carriage for materials and for coal, which is often needed in addition, and extra carriage for finished products, and very often extra cost of labor, as labor is often dear and bad in water-power districts. It may thus easily pay to use much more expensive power if the other conditions are more favorable. Steam power, for instance, will cost three or three and a half times as much, and yet it pays to make electrolytic caustic and bleach in England where the other conditions are all favorable. It is not, therefore, the want of water power that has kept the electrolytic industry back in this country. For a water power to be really valuable, it should be near a source of material, on the sea, and should have a great head of water, so that the capital cost of development is small. Such a water power is very valuable to the landlord.

A blast furnace is more valuable than a water power. There are plenty in England. But the owners, who have been wasting the gas up to now, will not give away; they will want rent, so that it will only pay to use this gas rather than make it. The electrical industry thus does not gain, but the iron-master does.

CARBON CELLS.

For many years, "electrical energy direct from coal" has been the dream of the electro-chemist. That is to say, he has dreamed of an electrolytic cell in which

* Abridged from the inaugural address by the president of the Institution of Electrical Engineers, Mr. James Swinburne.

the consumed electrode is carbon. The best way to realize the difficulties of this problem is to consider it solved and see what it means. The carbon must be in contact with an electrolyte, and that electrolyte must either be in contact with a second electrolyte which wets the other electrode or must itself be in contact with that electrode. This second electrode must almost certainly be metal, as there are no other non-metallic conductors available. Such compounds as the hydrides, nitride, oxides, chloride, bromide, or the sulphide, or silicide, of carbon are not salts in the electrolytic sense. Carbon forms part of the electro-positive radicle in the organic radicles and part of the electro-negative radicle in the cyanogen compounds, but it is never a radicle by itself. To sum up the matter shortly in the light of modern theory, carbon never forms ions, and has therefore no solution pressure, and can therefore give no electromotive force. At ordinary or moderate temperatures, carbon is practically inert. Oxidizing agents will attack some forms slightly, and sulphuric acid will attack it. In this latter case, the formation of water and its combination with the acid is the determining factor. At high temperatures, oxygen, sulphur, silicon, and to some extent nitrogen, and many of the metals combine with carbon, but there is no dissociable salt of carbon formed. The carbon cell thus seems impossible. Such schemes as Mr. Reed's, ingenious as it is, is not a solution of the problem. It would be simpler to reduce zinc oxide with the carbon and then put it in a zinc cell.

It is hardly necessary to discuss thermopiles or thermo-magnetic engines as possible economical producers of electric power.

STEAM ENGINES.

The primary question in all heat motors is, What temperature range is available? In the case of a steam engine there is enormous waste of mutivity—to use a variation of Lord Kelvin's convenient term—in boiler flues. We burn carbon and hydrogen, capable even with air of giving a temperature of some 1,500 deg. C., and the heat is degraded down to some 200 deg. C. That is to say, instead of getting the heat with a mutivity of about 0.825, we degrade it down to say, 0.35, a clear loss of 0.45 out of 0.8, or 56 per cent. This degradation is apart from the efficiency; the efficiency is concerned with the loss of heat up the chimney. The higher limit in large modern reciprocating engines may be taken, roughly, at 600 deg. A. (327 deg. C. or 620 deg. F.) Above this, there is difficulty in lubrication and to some extent weakening of the material. The pressure corresponding to this temperature for saturated steam is out of the question, and the pressure may be taken at, say, 12.5 megadynes per square centimeter or 12½ atmospheres, or 200 pounds per square inch, and steam leaving the boiler superheated to 600 deg. A. does not get at the cylinder lubrication at that temperature. Our limits in the steam engine are thus pretty clearly defined. The pressure is the essential factor. Superheating is not much good in the way of getting higher mutivity in the boiler, nor is it very important in getting much more energy into the steam.

The turbine is under the same limit as regards pressure; in fact, high pressures are perhaps even more difficult to use, and superheating does not, as already explained, seriously increase the mutivity of the heat taken in by the boiler.

One of the chief disadvantages of steam engines for stations with small load-factors is the difficulty of storing energy so as to get uniform boiler load. Batteries are no longer used for this, and the difficulty reduces the value of steam in comparison with the gas engine. Mr. Druitt Halpin has proposed, and used, "thermal storage." Lagged vessels are filled with water raised to the temperature of the working steam. This arrangement, however, is not isothermic; that is to say, to get out the energy the temperature must fall. What is wanted is a reservoir containing something which undergoes a physical or chemical isothermal change. For instance, a substance that fuses at the right temperature and has a high latent heat of fusion, or substance which, like sulphur, changes allotropically with considerable change of internal energy, at a suitable temperature. Unfortunately, there is no substance within the range of practical engineering. Moreover, the storage is on the wrong side of the engine. To store heat with a mutivity of only some 0.35 is not so promising as to store some higher form of energy. The secondary battery thus begins with an apparent advantage. The difficulty of storage is another drawback to the steam engine, and gives the gas engine a further advantage.

THE GAS ENGINE.

There is no other comprehensive name that covers the type of engine worked by gas and oil. The combustion need not be internal, and perhaps will not be internal in the future, but in a sense all are worked by gases.

We have in the gas engine a machine which, from a thermo-dynamical point of view, ought to be exceedingly good; but the difficulties in building, especially very large engines to utilize the high possible mutivity and saving by having the heat produced where used, reduce the efficiency of the gas engine enormously. In spite of that, the large gas engine seems likely to oust the steam engine for large powers during the next few years. The best way to get a high efficiency out of a gas engine would probably be to make it compound, exhausting at a temperature suitable for raising steam. The steam engine would then exhaust at a temperature suitable for raising SO_2 vapor. But the chances are that Dowson, Mond, or other producer gas will be available at such low prices that the extra steam and dioxide engines would not pay for attendance, interest and depreciation. With very cheap gas, the first thing is to make big engines, the next to make them so that they never break down, and the last thing to make them efficient. The gas engine may be, comparatively speaking, in the state Watt left the steam engine, but it will doubtless make very rapid advances, as it is in the hands of very competent and highly educated engineers.

DYNAMOS.

As regards efficiency, we have reached the practical limit already, for further reduction in dynamo losses would make no appreciable difference in the total efficiency of a station. In fact, we are rather following continental practice in having slow-running machines with many poles, even for direct currents, and efficiencies are perhaps lower for large machines than in the best English practice of a few years ago. This is also true as regards output from a given size. We are not likely to make much advance in dynamos now, as we are limited on one hand by the hysteresis loss in iron, which prevents our using higher inductions in armatures, and low permeability, which limits our field and armature tooth inductions. It does not seem likely that we shall now find iron much better in either respect. Nor are we likely to find a better available conductor than pure copper. As insulator we have mica. It looks, therefore, as if we were within sight of our limits in dynamo and motor designs.

SECONDARY BATTERIES.

The secondary battery in central station work has been used as a store to equalize the load, and to reduce the running plant at the times of heavy load. Owing to the high full-load station pressure with feeder systems, the station battery is generally for use at light loads only. But the secondary battery has for a long time been on the border of success for traction work, both on tramways and on the road, and a further improvement in batteries may be expected to produce very great changes in important branches of engineering.

The first question asked is, Why do we stick to lead? The answer is that the case is very special and other things will not do. We are practically limited to lead, at any rate in acid cells. Take first the plate that oxidizes on discharge. It should not dissolve in the electrolyte, as if it does the deposition and solution will be uneven, and the plate will grow trees and come to grief. This puts zinc out of court, unless some electrolyte is used which gives some insoluble salt of zinc, which does not attack zinc on open circuit, and gives a good electromotive force with it. Iron is out of court for the same reason; there is no suitable electrolyte. The strong organic acids such as tri-chloracetic or oxalic are apt to have their positive radicles split up by electrolysis, even if a strongly positive metal can be found with an insoluble salt. Lead is thus the only metal practically available in an acid electrolyte. Silver in hydrochloric acid would give no pressure, and the acid would be decomposed at the anode. On the other plate we need an insoluble depolarizer, else a two-fluid cell must be used, involving a porous diaphragm, diffusion and impracticability. Not only must the depolarizer be insoluble, but it must be converted into an insoluble body on discharge. The coating must be a conductor in one state or the other, or there will be no proper contact. In the lead cell, there is always enough peroxide and metallic lead in the coatings to secure electrical contact though the discharge product is an insulator. The depolarizing coating must be connected to a conducting plate which is not attacked by local action. Lead and silver are the only available metals, and sulphuric, and perhaps phosphoric, the only acids, for the nitrate of lead is soluble and hydrochloric acid is decomposed by lead peroxide. Lead is protected by its coating of sulphate, or peroxide as the case may be. It thus seems as if we were limited almost absolutely to lead and sulphuric acid. It is wonderful that we have the lead cell at all. We owe it to the chance observation of Planté. The theory was not understood for a long time. For many years it was thought that the pressure was due to the PbO_2 and Pb changing into PbO. The acid was merely put in to make the electrolyte conduct, and sulphuric acid was used because people used it in gas voltameters, and they never thought that it ought to be as strong as practicable to give the pressure and output. The formation of lead sulphate was regarded as a difficulty to be overcome.

In the lead cell we want lightness, large capacity, cheapness, rapid discharge, efficiency, and mechanical strength, and durability. These qualities are mostly antagonistic. Large capacity means rapid deterioration. Mechanical strength means weight. It is thus no use testing a cell for capacity without testing the efficiency and durability too, and so on. Published battery reports are often misleading, because they omit essential information.

CABLES.

The conductor itself can hardly be improved, but there is great room for improvement in the insulation. It is largely the insulation of the cables that limits our pressures, and therefore our distances of transmission. For 1,000 kilowatt cables, the cost is about a minimum for 8,000 volts; above that, the cost of insulation increases faster than the cost of copper falls. It is exceedingly unlikely we have reached the limit in insulation. There is no branch of electrical engineering so important as cable making. Cables form a large portion of the capital outlay in large systems. Yet there is no branch of the industry which is run on less scientific lines. The days of secret mixtures known only to the workman who makes them may be passing away; but even now the whole art of cable-making is a question of trial and error, with a good deal of the last component. Engineers do not know now whether rubber is better than paper, nor can they tell what any particular make of cable will be like after ten years' use.

LIGHT.

Our chief work, until lately, has been producing light. Here the inefficiency and waste is prodigious, and though it is mostly unavoidable, there is still great room for improvement. We take great care over our stations, watching every penny from the coal shovel or mechanical stoker to the station meter. We quarrel over 1 per cent in the generators. When we get to the mains we care less, and once we have got to the consumers' meters we care nothing at all.

Practically all light is wanted for use by the human eye. The human eye is exceedingly sensitive; it is calculated to see a distant star when receiving 10^{-8} ergs per second, so that one watt would enable, say, five thousand billion people to see stars with both eyes, but it would have to be used economically. In reading a book, the eye would need much more than this; and then, as the book radiates light in half of all directions, only a little is used by the eye, so even if all the light from a source were concentrated on a book, there is enormous waste by useless radiation from the book. But the source of light does not illuminate only the book; the book probably subtends a small solid angle, so we have another source of waste. The eyes reading a book in a fairly good light want something of the order of two ergs per second, so that a watt would only work the optic nerves of, say, the inhabitants of London. But the book, say 200 square centimeters, would need about 3,000 ergs a second to illuminate it. A candle, which gives a light of 4π radiates about 0.2 watt, or five candles a watt; that is to say, at an efficiency of unity, we would get five candle-power or 20 units of light per watt. The efficiency of a glow-lamp is only about 0.25 candle-power per watt, or 0.05, so there is room for improvement. The first thing, naturally, is to see what limits there are in the way of increased efficiency. The obvious goal is direct production of "light without heat," by which is meant producing only the rays of wave-lengths which affect the eye.

There is no thermodynamical reason why electrical energy should not be converted directly into radiation of any wave-length without loss; I do not know if there is any molecular impossibility, but apparently our limits are practical—that is to say, it may be done, but we have not yet hit on the way of doing it. The vacuum tube appears to be a means of converting electric power direct into radiation. The Cooper-Hewitt lamp, for instance, gives an efficiency of about three candles per watt, or something like 0.6. All these figures as to light are a little vague. Unfortunately, the light is of a very bad color. It is very actinic, but the wave-lengths are too small. One method is to degrade the light by making it act on silk dyed with matters which lower the radiation to a redder color by fluorescence.

THE ARC LIGHT.

The arc has been very fully studied in some directions and not in others. Most makers of arc lamps seem to devote their whole attention to the mechanism, and look upon the arc merely as a hot gap that has to be preserved by suitable apparatus. Many lamp makers, on the other hand, have records of exhaustive experiments on the relations of the pressure, current, and light with different carbons; but they are very seldom published. On the other hand, an enormous amount of laborious experiment on such points as these is available, and on the back electromotive force of the arc. The physics of the arc, an exceedingly difficult branch of study, has not received much systematic attention yet. The crater of an arc is, no doubt, heated to the point of volatilization of carbon at the pressure of the air. If other gases get at the crater, the vaporization temperature would be less. (There is a small increase of pressure which I suggest is due to the electromagnetic effect of a current localized in a conducting fluid. This may be neglected.) The crater may be rough, as carbon, though it softens, does not melt before volatilizing, and it may be merely speckled with points at its volatilizing temperature, so that its brightness is not uniform. But there are so many anomalies about the arc that one cannot say anything definite with safety. For instance, if the temperature is limited by the vaporization of carbon, what must be the specific heat of vaporization of carbon? Where does the vapor go, and what happens to it in an inclosed lamp? In condensing into smoke, it should give light of the same color as the crater. If it has an enormous specific heat, it ought to raise the other pole to crater temperature where it condenses. If it is a light gas, a larger portion of its specific heat of vaporization may go to external work. Most of the upper carbon is burnt away by external air; if a pencil to match the crater is volatilized, it does not account for much power. If the vapor is very light, there must be large volumes from the upper carbon. Then what conducts? Carbon vapor alone, or mixed with a little monoxide or nitrogen, is a very good conductor at these temperatures. Does that go to show that carbon vapor dissociates like iodine or chlorine, etc.? The whole question of the physics of the arc deserves far more careful study than it has yet received, but the work is surrounded with difficulties and is really a branch of the theory of the passage of electricity through gases, a matter of the greatest scientific importance, somewhat out of our way as practical electrical engineers. But as engineers in the broader sense, we are as much interested in questions of recondite physics as of costs of generation.

To sum up as to the arc light, we do not seem to have reached our limit as to light from pure heating, because we lose a lot of light into the opposite carbon. Many attempts have been made to expose the crater freely. But, far more important than this, I would urge that the arc is not necessarily a hot body radiator only, but that it may also convert electrical power directly into light in the space between the electrodes, and this gives a chance of rising more nearly to our theoretical limit of about five candles per watt.

THE INCANDESCENT LAMP.

This simple hot carbon wire in a bulb involves the most extraordinary physical complexities. A great many curious things go on inside the simple-looking globe. A good account of what is known—especially since he took the subject in hand—has been written by Dr. Fleming, and the scientific manufacture of this interesting article has been fully described by Mr. Ram. The incandescent lamp is a simple hot body radiator, and the limit of efficiency depends chiefly on the temperature of the carbon. As we are limited by the size of mains, we can only use pressures of 100 volts or 200 volts, and this limits us to carbon or something of still higher specific resistance. The sensitiveness of the carbon lamp to pressure in its turn limits the practical variation of pressure of supply, and thus costs us very heavily in mains. If we had incandescent lamps which did not mind 20 per cent pressure variation, we would have saved millions in mains in this country alone.

The idea of making lamps of carbides has become very fashionable lately. People have put oxides into carbon for the last twenty years. The old idea is to get hold of an oxide that radiates more light at a given

temperature than it ought to, which is itself a fallacy, while the idea of oxide in contact with carbon is chemically absurd. There is no oxide irreducible by hot carbon. The carbides are not by any means all refractory. Some are, though, but there are immense difficulties in making carbide lamps. To make a fine filament material of an infusible material, which can be made only at electric furnace temperatures and is generally decomposed by moist air, is not an easy task. It is easy to think you have made a carbide lamp by incorporating an oxide in the filament material, but the resultant filament is generally mostly, if not wholly, carbon. What happens to the metal in the circumstances is rather a mystery. There is, however, a chance of enlarging our limits in incandescent lamps of the ordinary kind, but it seems strange that the melting points of all known materials should suddenly reach a higher limit. Assuming the Stefan-Boltmann law for ordinary light radiations, the fact that the efficiencies of refractory bodies all reach limits of the same order shows that the most refractory bodies melt at about the same temperature, somewhere in the neighborhood of 3,000 deg. A. Whatever the intermolecular forces may be that bind the particles to make solids, the vibration forces due to temperature seem to overcome the greatest at about 3,000 deg.

Instead of an ordinary conductor, Nernst uses an electrolyte which stands a higher temperature. The conduction is electrolytic, as can easily be shown, but there are many curious phenomena, many of them so far unexplained, in the Nernst lamp. The efficiency of the Nernst lamp is about 0.6 candle per watt. It was at one time supposed to owe its efficiency to selective emission, but there is no reason to doubt that it is a pure temperature radiation.

ELECTRIC HEATING.

The limit of electric heating is clearly purely financial. To convert heat into other energy with a very small efficiency and to send it out by expensive cables and then to degrade the energy down to heat again is obviously much dearer than burning coal or gas direct. But in many domestic cases, the convenience is so great that the limit is not so low as might be thought, and electric heating for cooking and other domestic uses may develop considerably. The electric arc and incandescent lamps are essentially cases of electric heating. By far the most important use of electric heating is the furnace. Here the temperature available is only limited by the volatilization of the electrodes, and this enables us to get temperatures otherwise unavailable, so that we can get chemical actions which are impossible at lower temperatures, either because they are endothermic or because the materials do not come into chemical contact at ordinary temperatures. It is impossible to say what our limits are in the electrical furnace. Probably the temperature is limited by the volatilizing of carbon. The products are not limited to endothermic compounds; the furnace is useful for the reduction of metals and phosphorus, and for melting glass and, it is hoped, silica for optical and laboratory purposes, and perhaps for cooking utensils and evaporating pans and crucibles in chemical engineering and metallurgy.

RAILWAYS.

It is almost absurd to begin to consider the limits of the use of electrical transmission on railways at this date. The future of electric railways, electric tramways and automobiles is rather a matter of vague conjecture and picturesque prophecy. Tubes are multiplying rapidly, and railways are putting down electric transmission on suburban lines in Europe and the States. On short lines with many stops, we have to contend with inefficiency at starting. On long lines, there is difficulty of transmission or cost of transformation and difficulties of collection. We are limited by the want of either a variable speed simple alternate-current motor or a simple variable speed-gear capable of transmitting a very large torque and packing into an engine. A recently developed scheme is the use of low-frequency alternating currents with laminated series-wound motors. This solves the difficulty, but at the expense of large idle current, induced pressure in short-circuited armature coils, large expensive and inefficient transformers, and the ordinary disadvantages of the series-motor on constant pressure. This plan is well worth serious study.

The collection of large currents at great speeds has long loomed as a limit. The published accounts of experiments at Zossen would lead us to suppose there is no trouble on this score. Still, it is a difficulty many engineers fear.

In electric tramways, there is no limit in sight. The power can be sent over any distance desired, and there seems to be no limit to the people who want to travel on electrical trams. The question of electrolysis is rather that of a limit to the duration of pipe companies' property. It is a very difficult question. Though the threatened effects of electrolysis have no doubt been exaggerated, it is at best a question of degree, and the ingenuity of engineers is continually reducing the chance of damage. It has recently been urged that frequent reversals of polarity of the system reduce the electrolysis very considerably.

ELECTROLYSIS.

This is a branch of industry in which it is very difficult to tell our limits. In electrolytic copper-refining, our limit is that of the copper wanted. Our electrolytic industries suffer mostly from the limits of intelligence of the investing public. It is assumed that we cannot do electrolysis in England because we have no water power. This is only an excuse for inactivity. As already explained, we can do just as well without water power. A blast furnace is much more valuable than a waterfall of similar power, because it is near coal and in an industrial district. Moreover, as already explained, the cost of electrical energy is a small portion of that of most electrolytic products. At first, electrolysis was to be applied to copper-refining. Then to caustic soda. The output of electrolytic caustic is really rather limited by the demand for bleach. What is urgently wanted is some other way of storing and carrying chlorine. Steel bottles and compression plant are an unsatisfactory solution. What are the limits in the way of electrolyzing fused salts? They are all incidental limits. The containing vessel is a difficulty. Sodium vapor attacks all silicates. Sodium distills near the temperature of fused salt. If not volatilized, it forms a conducting bridge from the kathode. It attacks iron, though slowly. Hot porcelain and earthenware conduct electrolytically—as, by the way, the maker of electric frying-pans knows—hot chlorine attacks metals, even when dry, and hot carbon cannot be exposed to the air. In addition, sodium, and perhaps chlorine are soluble in hot salt, and traces of sulphate in the salt act as carriers. I could a tale unfold if I read out laboratory notes of sodium experiments on a fairly large scale. The difficulties are all incidental, though, and I have little doubt electrolytic sodium at a few pounds per ton will be in the market soon, and will affect profoundly many chemical and metallurgical industries.

In metallurgy, electrolytic solution processes are in use or on trial for the more valuable metals, such as copper and nickel. The reaction between chlorine and metallic sulphides at high temperatures brings the whole domain of sulphide ores under our sway. Thus a sulphide, say galena, is treated with chlorine, which gives off the sulphur as sulphur, which is condensed and sold, making chloride of lead. The silver is extracted by stirring with a little lead, and the fused salt is then electrolyzed, yielding pure desilverized lead and chlorine. The process is thus self-contained, yielding sulphur, lead and silver. It is specially applicable to mixed refractory ores which are now nearly valueless and very plentiful, and contain much metal content, such as the mixed lead-zinc sulphides of America or Australia. These reactions have been proved on the large or ton scale, and there is no technical difficulty. Unfortunately, mine people are somewhat ignorant of electrical matters, and it is exceedingly difficult to get them to understand or appreciate a process like this, capable though it may be of paying good dividends on very large capitals indeed.

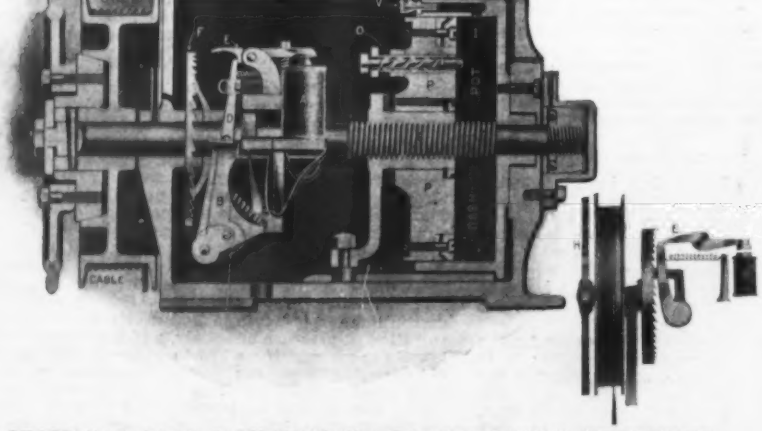
Our limit in electrolysis in this country is almost entirely human inertia. Commercial and financial people do not understand it, and fight shy of it. But our technical people are nearly as bad. The pure physicist, as a rule, takes no interest in electrolysis or physical chemistry, and thinks it belongs to the chemical classroom on the other side of the passage. The chemist thinks it is higher mathematics and will have none of it, the mathematician thinks it may be an exercise in differential equations; but they are all agreed that it is a sort of Continental fungus which flourishes with no roots, and that it is beneath the attention of a scientific man to know enough about it to give a reason for the broad statement that it is all nonsense.

THE ENGINE STOP WITH ITS COVER OPEN.

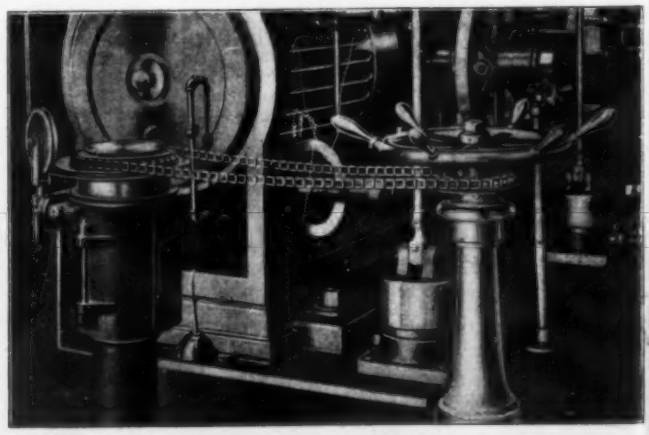
AN IMPROVED SYSTEM OF ENGINE STOPS.

SHOP tools and factory machines are usually driven from a central source of power comprising one or more engines. Should these engines for any reason be injured, the entire shop or factory system is immediately crippled. Moreover, accidents may arise through the sudden throwing-off of loads, as by the breaking of a belt, by which considerable loss of life and property may be caused. The efficiency and safety of the plant are increased as the possibilities of accidents are lessened. That devices should have been invented for the purpose of stopping an engine in cases of emergency would follow from the very existence of such emergencies. It is the purpose of this article to describe a system of engine stops which has earned for itself no slight reputation for efficiency.

The system in question, introduced by the Consolidated Engine Stop Company, of 100 Broadway, New York, under the name of the Monarch System, consists essentially of four units—the engine stop for automatically closing down the engine in cases of

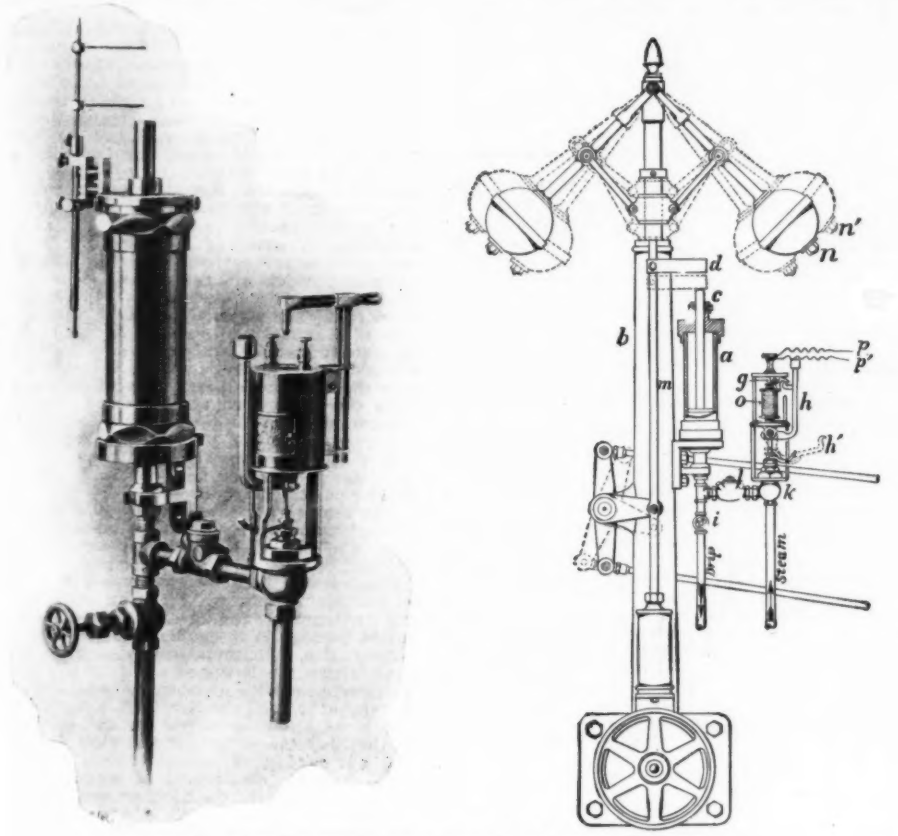


SECTIONAL VIEW ILLUSTRATING THE OPERATIVE MECHANISM OF THE MONARCH ENGINE STOP.



THE MONARCH ENGINE STOP APPLIED—VERTICAL EQUIPMENT.

emergency; the speed limit for automatically checking an excessive speed of the engine; the vacuum valve for automatically opening communication between the interior of the condenser and the atmosphere, and the circuit-breaker trip for automatically tripping the circuit-breaker in cases where generators are operated in multiple. Each of these four units performs its function automatically when the necessity arises. The whole insures both the safety and integrity of the plant.



CORLISS ENGINE STOP AND DIAGRAM OF MECHANISM.

The purpose of the Monarch engine stop is to provide a means of stopping the engine at times when promptness is the main thing to be considered. By means of the stop the engine can be closed down from any part of the building by closing the circuit with push button, snap switch or any form of circuit closer desired. The various buttons operate the stop through electrical connection. These buttons may be located at convenient points, and can be protected from meddlesome employes; their number is not limited. The means to stop the engine are ready at hand at the most remote place of factory or shop. The stop works almost instantaneously, for the throttle valve is closed from three to ten seconds after the button has been pushed—much more quickly than any human hand can work. An electric gong is rung automatically when the stop is operated to notify the engineer.

The mechanism of the stop is inclosed in a cylindrical iron case or shell, the upper half opening on hinges. Passing through this shell or case, turning on ball bearings, is a steel shaft 1½ inches in diameter, on the outer end of which is attached a drum or pulley to which is bolted a sprocket *H*, as indicated in the detail view. Around this drum passes a wire cable *G*, to which is attached a weight which furnishes power to operate the device. Inside the case and fastened to the shaft is a ratchet-wheel *F*, engaged by a pawl *B*, which prevents the weight from turning the shaft in the direction that closes the valve. This pawl is held in engagement with the ratchet by a vertical lever *D*, held in position by the left end of the armature-lever *E*. The magnets *A* are placed in circuit with an electric battery, and when the circuit is closed by pressing a button, the armature end of the lever *E* is pulled down, releasing the upper end of the vertical lever *D*, which also serves as a hammer, striking a lug on the pawl *B*, throwing it out of engagement with the ratchet, thus allowing the shaft of the stop to revolve and close the valve, by means of a link belt attached to the sprocket-wheel of the stop engaging a similar sprocket wheel attached to throttle-valve stem, the weight as before mentioned furnishing the power. At the opposite or right end of the stop is a dash-pot which consists of a cylinder into which the piston *P* fits closely. On this end of the shaft is cut a square-threaded screw *S*, passing through a nut fastened in the center of piston *P*, so that, as the shaft revolves, by means of this screw, the piston is carried into the cylinder, and the air behind its inner face is compressed, forming a perfect cushion. The speed at which the stop acts may be varied by turning the by-pass valve *V*, governing the amount of air that is forced through the air passage *I* as the piston moves in. Below this by-pass valve *V*, and in piston *P*, is located the adjustable releasing-valve *O*, which is opened by contact against the bottom of the dash-pot. After the piston has cushioned and the throttle-valve of the engine is near its seat, the compressed air in chamber *I* escapes through this releasing-valve *O*, allowing the throttle-valve to take its seat softly, but yet with sufficient force to close it tightly.

Among the most disastrous accidents which occur constantly are those due to the bursting of flywheels on running engines. Such accidents cause the loss of many lives, and entail an enormous loss of money by reason of the damage done to machinery and property. The Monarch speed limit is a device for automatically preventing the excessive speed of an engine, and hence obviating just such accidents. The maximum speed is never allowed to approach the danger point. The speed limit is directly connected with a main flywheel-shaft and can be set to act at any number of revolutions. When the speed of the engine exceeds the desired number of revolutions, the speed limit operates the stop automatically by electric contact immediately shutting off the steam. The limit is closed in an iron case, which occupies the small space of 7 x 12 inches. The construction comprises a pair of governor springs arranged on a horizontal shaft and provided with the usual balls. When the speed increases beyond the desired point, the balls, separating by centrifugal force, move a sliding collar on the shaft with which they are connected, until the collar comes in contact with two electrical terminals. Thus the electrical circuit is completed, and the stop operated. These terminals can be adjusted at will, so that the circuit is not closed until the engine reaches any desired speed.

The Monarch vacuum-valve creates a vacuum in the condenser automatically, and prevents the cylinder from taking water when the throttle is closed and the pressure shut off. It is operated by electrical connection with the stop, simultaneously with the shutting off of the steam. The vacuum-valve can be located at any desired point. The device consists of a cylinder connected with the condenser, and is provided with a port which is closed against the atmosphere by a valve movable up or down in the cylinder and operated by a horizontal lever. This lever is held in position by the right trigger end of an armature lever. The magnets are in circuit with the electric battery, which operates the stop; when the circuit is closed by means of the push buttons, or automatically by the speed limit, the armature-lever is pulled down, releasing the horizontal lever, thus allowing the spring to operate and lift the valve, and opening the port in the side of the cylinder to allow air to flow through the connecting pipes into the condenser.

In electric light and power plants, or in any place where generators are operated in multiple, it often becomes necessary to provide some means of opening the generator circuit simultaneously with the closing of the throttle. It is this end which is accomplished in the Monarch system by the use of the circuit-breaker trip. This device automatically trips the circuit-breaker in the generator circuit at the time the throttle-valve is closed by the stop. Sometimes it becomes necessary to apply the engine stop directly to the governor instead of to the valve. For this purpose the Corliss engine stop has been designed. Although differing in mechanical construction from the stop previously described, it is nevertheless similar in so far as it is operated automatically. The machine consists of three parts of a cylinder which is attached to the governor column, a valve for admitting steam to the cylinder, with an electro-magnet for releasing the valve, which may be placed in a convenient position, and, finally, the speed limit.

The valve *k* is held closed by the armature *g* of the electro-magnet *o*. When the circuit *pp* is closed, the movement of the armature *g* releases the lever *h*, which in turn releases the valve *k*, allowing the steam to open the valve and pass into the cylinder *a*, and to force the piston *c* upward. This engages a clamp *d* attached to the side rod *m*, and raises the governor balls *nn* to their highest position *n'n'*, and by the check-valve *l*, they are held there, thus preventing the grab-hooks from opening the main valves.

Simply by replacing the lever *h* and opening the drip valve *i*, the governor is allowed to slowly settle to its natural position. It is then necessary for the engineer only to rock the wrist plate forward and backward to set the valves in the proper position to admit steam. The engine is then ready to start.

The system just described has been installed in many of the biggest plants all over the country where steam is used for power. The increase in the use of electric motors for power purposes has shown the need of a device which will do for the electric motor what the engine stop does for the steam engine. This want has been met by the Monarch motor stop, an exceedingly practical apparatus, which places an electric motor or a motor-driven machine under absolute control from any part of the works. Snap switches of the improved dial pattern are placed at different points wherever desired, and one turn of the switch operates a separate battery system which throws the main switch at the board. These switches are always available for immediate use, but are protected from meddlesome and unauthorized employes. The switchboard is a sheet of marble or slate carrying a testing apparatus as well as the main switch. The board itself can be used as a main switchboard or it can be placed in the office or other part of the plant and used only in emergencies. The apparatus can be tested from the switchboard to detect low battery power or short circuits. The system of wiring is patented and is so simple that chances of trouble with it are extremely remote. The Monarch motor stop can be connected with any size of motor using any kind of current. It will stop a machine under load in two to five seconds, and can be applied to protect the whole line, or a limited number of motors or a single motor. This new apparatus gives the company a system of power-control and speed-limiting

MONARCH VACUUM VALVE.

devices which meets every requirement for electric as well as steam-driven machinery.

Both in connection with the motor stop and the engine stop, a patented system of wiring is used by which every foot of wire throughout the building can be tested and a breakage or low batteries detected. The test may reveal a broken wire or weak batteries. Though attention is given to them at once, it might happen that there would be necessity for shutting down the engine for some accident pending the repair of the wires. If such be the case, by the system of wiring described, every button in the plant would be available so that the system would not be crippled for a moment. Only when the wires are broken off at both sides of a button, a very remote possibility, would the system be crippled. The possibility, however, of a single break somewhere along the line is quite obvious, but the system of wiring will detect this. Yet the engine stop or motor stop will not be crippled in any way as above mentioned.

The engine stop or motor stop can be operated from the lighting current. Only about ten or twelve volts are required, but by using resistance coils, the current can be taken from a 110 or 220 volt system in the building, thus dispensing with batteries.

MEMBERS OF THE ARGON GROUP.

FROM a paper by Henry P. Talbot, published in the Technology Quarterly, M. I. Wilbert presents in the American Journal of Pharmacy the following facts and figures concerning the argon group:

Argon.—The circumstances that led up to the discovery of this element may be found in the fact that Lord Rayleigh, in the course of some experiments, had noted that atmospheric nitrogen appeared to have a greater density than nitrogen obtained from chemicals, such as nitric acid, nitrous oxide or ammonium nitrite. Suggestions and explanations were numerous but unsatisfactory, and it was finally decided to determine whether or not there was an unknown heavier element in the atmospheric nitrogen.

In making these investigations Lord Rayleigh had associated with him Prof. Ramsay, of University College, London. After a long series of carefully planned and executed experiments, Lord Rayleigh and Prof. Ramsay, on January 31, 1895, made the announcement, at a meeting of the Royal Society in London, that they had discovered a new element in the atmosphere, to which, on account of its inert character, they had given the name argon. The quantity of this element, present in the atmosphere, appeared to be about 1 per cent of the contained nitrogen, or about 0.9 per cent of the atmosphere. Assuming that the density of argon was about 20, it would explain the greater density of atmospheric compared with chemical nitrogen. Argon has since then been found in one specimen of meteoric iron, in a variety of minerals and in the waters, or escaping gases, from a number of springs in different parts of Europe.

So far it has not been definitely demonstrated to have any chemical properties. Its physical properties, that is, its spectrum, its specific gravity, and the atomicity of its molecule have been the subject of much research and discussion. Its spectrum for instance appears to vary with the nature of the electrical energy that is used to energize the gas, and is admittedly complex and varied. This complex nature of the spectrum, as well as the accompanying variations, has been made a basis for arguments against the elementary character of argon.

The density of argon has been carefully determined by Ramsay, who, as the result of numerous experiments, announced 19.96 as the true value for the density of the gas; this would correspond to a molecular weight of 39.92 (O=16).

Helium.—This element was first noticed in the spectrum of the chromosphere during an eclipse in 1868, by Janssen, who noted a brilliant yellow line, which was close to but not identical with the well-known D-line of sodium. This he designated as the D_3-line, and in the same year Lockyer assigned the name "helium" to the hypothetical element, of which this line was characteristic.

While this line has been repeatedly observed since then, by projecting the image of the edge of the sun on the slit of a spectroscope of wide dispersion, and has also been found in the spectrum of some of the fixed stars and nebulas, it had never been demonstrated to exist among terrestrial elements.

After the discovery of argon, Mr. Myers, the mineralogist of the British Museum, wrote to Prof. Ramsay, calling attention to the fact that cleveite (a uranate of lead, thorium and uranium) had been shown by Hildebrand to contain nitrogen. Myers offered the suggestion that this mineral might contain argon or might have some constituent capable of entering into reaction with argon.

This suggestion was later adopted by Prof. Ramsay, who demonstrated that the resulting gas, after removing the nitrogen, not only contained argon, when subjected to spectrum analysis, but showed a new series of lines in the red, green, blue, and violet and notably a brilliant yellow line. Ramsay later sent the gas to Crookes for examination and he in turn reported that the bright yellow lines were undoubtedly due to helium. Experiments made gave 3.89 as the maximum density of the gas, and the ratio of the specific heats was found to approximate 1.66.

The gas is then, as was to be expected from its existence in the chromosphere, very light, and it appears to be monatomic.

Helium has been found in a number of minerals almost all of which contain either uranium, yttrium or thorium. It has been found in the gas emanating from several of the European thermal springs and has been definitely proven to exist in liquid air. From observations that have been made it has been determined that this element is one of the constituents of our atmosphere in the ratio of 1 or 2 parts in a million. The latest determinations of its density appear to make it about 1.98 and its atomic weight about 3.96.

Other Members of the Group.—Prof. Ramsay, in a lecture before the Deutsche Chemische Gesellschaft in December, 1898, gave an account of the steps which led to the discovery of the other members of the group.

The search for these elements was occasioned by an attempt to fit argon and helium into the periodic system. If 4 and 40 were assumed to represent the atomic weights of helium and argon respectively, there would be a space to be filled by an element having an atomic weight about 16 higher than helium.

The quest, begun by Ramsay and Collie and continued by Ramsay and Travers, opened with a careful re-examination of the minerals which had proved to be a source of helium. The search was later extended to other minerals of different chemical character, but with uniformly negative results. Meteorites and the gases from mineral springs were equally unproductive.

Attention was then turned to argon, and its study in connection with liquid air. It was pointed out that the atomic weight of argon would be more tractable if it could be reduced to below 40, and a search after a constituent of the air having a lesser density than 20 seemed worth the making.

In preparing to liquefy a quantity of purified argon, with the aid of liquid air, it was thought worth the while to examine the last fractions of some evaporating liquid air. After removing the oxygen and the residual nitrogen, Ramsay found that there were present, in the spectrum of the residual gas, a number of the new lines, notably a yellow line not identical with that of helium, and a new green line. The gas had a density of 22.5 instead of 20 and the ratio of specific heats of the mixture of gases was found to closely approximate 1.66. Here, then, was a new element or elements, but not the one sought for. Ramsay, assuming the presence of one only, gave it the name "krypton" (the concealed one).

The gas has been studied more closely since that time. It is estimated to be present in the atmosphere in the ratio of about one part of gas to a million of air. The density of the gas is estimated to be about 40.78 and its atomic weight 81.56.

In the subsequent experiments that were made with liquid argon it was found that the first fraction, from the boiling argon, had a density of 14.67 and a ratio of specific heats of 1.66; the spectrum showed, besides the lines of argon, a number of new lines of red, orange and yellow of marked brilliancy. After some further separation of the contained argon the density was found to be 9.76. This new gas, which was designated as "neon," while it still contained a fraction of argon, also contained helium, which would tend to decrease the density of the mixture somewhat.

Later experiments appear to indicate that this gas has a density of about 9.96 and an atomic weight of about 19.92. It is present in the atmosphere to the extent of from 10 to 20 parts in a million. The less volatile portions of the liquefied argon they considered to contain at least two additional elements besides krypton and argon. To one of these they gave the name "xenon" (stranger), and while they did not have an opportunity to study it in a perfectly pure condition, they determined its density as being from 40.5 to 41.1. Later investigations appear to indicate that xenon has a density of about 64 and an atomic weight of 128. It must be considered as an extremely rare element occurring in the atmosphere in the proportion of 1-20 of 1 part to a million of air.

The fourth component of the less volatile portion was given the name "metargon." It was a source of much perplexity, as its spectrum was found to resemble the so-called "swan spectrum" of carbon monoxide. Subsequent study showed that the supposed new element was indeed carbon monoxide which had been introduced by accidental impurities in the chemicals.

All of these elements are gases and all are chemically inert; it would appear self-evident, therefore, that they would form a distinct class of their own; but how to fit them into the existing periodic system developed a problem that has been attacked by several eminent European scientists, and has also been the cause of considerable discussion pro and con as to the elementary character of the substances, and the correctness of the available data concerning them.

Several schemes have been proposed to fit them into the periodic system in a rational and satisfactory way. The one proposed by Ramsay is given below:

H	He	Li	Be
1	4	7	9
F	Ne	Na	Mg
19	20	23	24
Cl	A	K	Ca
35.5	40	39	40
Br	Kr	Rb	Sr
80	82	85	87
I	X	Cs	Ba
127	128	133	137

It will be noted that hydrogen, according to this arrangement, becomes the first element in the halogen group—a position for it which had been suggested by several eminent scientists.

The inert group, according to this classification, would hold the position between the very active halogen and the sodium groups.—Druggists' Circular and Chemical Gazette.

ANALYSIS OF VULCANIZED CAOUTCHOUC.*

THE method which I proposed some time ago for separating caoutchouc from the mineral matters contained in it afforded practically very satisfactory results. This method consists in boiling the caoutchouc (which is cut in small pieces), with nitrobenzine in a balloon furnished with upright condenser. The only inconvenience is the difficulty of eliminating the mineral matter from the products of the decomposition of the caoutchouc. It is generally possible to guard against this inconvenience by adding to the solution a large quantity of ether. If we have to do with African caoutchoucs, the amount of ether must be considerable. Further, the treatment with nitrobenzine causes a phenomenon which I have recently observed for the first time.

On analyzing a slab in course of viscous decomposition (a) and another slab, prepared in the same way, but of faultless quality (b), I obtained the following percentages:

(a)	
Oily extract	8.35 p. c.
Caoutchouc	9.85 p. c.
Inorganic matters	79.90 p. c. (63.11 p. c. of mineral matter, 16.79 p. c. of carbon.)
Sulphur, total	1.89 p. c.
(b)	
Oily extract	2.82 p. c.
Caoutchouc	12.73 p. c.
Inorganic matters	82.34 p. c. (62.81 p. c. of mineral matter, 19.53 p. c. of carbon.)
Sulphur, total	2.10 p. c.

The presence of such considerable quantities of carbon and of carbonaceous substance on one hand, and the exceedingly small percentage of caoutchouc in the product on the other, raised some doubt as to the correctness of this analysis and a more thorough examination of the latter has only increased the doubt.

Under ordinary conditions, figures representing the "oily extract" would be attributed to the caoutchouc; for to the manufacturer the extract is an integral part of caoutchouc. But, in the decomposing samples the quantity of oily extract was almost triple that in the normal caoutchouc. The amount always varies considerably, according to the nature of the caoutchouc, yet so pronounced a difference as that observed between products *a* and *b* raises serious doubts. Besides, in the decomposed samples, the increase in the proportion of oily extract has as a result the diminution of the quantity of caoutchouc found, which seems to indicate that the oily extract is in greater part only a product of the decomposition of caoutchouc. Analysis shows that the proportions of carbon correspond with the proportions of caoutchouc. All these facts demonstrate that the carbon found in the analysis did not pre-exist in the product, but resulted from the action of the boiling nitrobenzine on the caoutchouc. It is also possible that its formation is due to the high boiling point of nitrobenzine.

The attempt has been made to dissolve the samples in question in nitrobenzine at a temperature from 170 deg. to 190 deg. C., but without result. Either the dissolution of caoutchouc was incomplete or carbon made its appearance in the same proportion as in the analysis mentioned above. Starting with the idea that the preliminary swelling of caoutchouc in chloroform might perhaps facilitate its disintegration by boiling nitrobenzine, I have introduced 3 grammes of each sample into the large-necked flasks which served for the treatment with nitrobenzine, added 3 cubic centimeters of chloroform for each test, stoppered the flasks and left them at rest for an hour. At the end of that time the caoutchouc was distended enormously. Without driving off the chloroform, I added to each flask 50 cubic centimeters of nitrobenzine, attached the bottles to upright condensers and heated the nitrobenzine to boiling point on a bath of paraffine. After an hour the operation was suspended and on cooling, 100 cubic centimeters of ether were added to the contents of the flasks, which were filtered. The results obtained were: inorganic matters, (a) 63.33 per cent; (b) 63.02 per cent. There was no trace of carbon. According to this experiment, the preliminary swelling of caoutchouc by chloroform prevents carbonization completely. The favorable action of chloroform in this respect is beyond question; but it must be taken into account that the addition of chloroform to nitrobenzine lowers the boiling point of the latter considerably. Direct experiment has demonstrated that a mixture in the above mentioned proportions of chloroform and benzine boils at a temperature of 170 deg. to 180 deg. C. To the action of chloroform at this temperature on the caoutchouc, I attribute the energetic disintegration of the latter.

The experiment, of which I have given a description, appears to show that the carbonization of the caoutchouc by boiling nitrobenzine was principally due to the influence of the high temperature, assisted perhaps by the oxidizing action of the nitrobenzine. But the exact determination of inorganic matters obtained in the two series of analyses have demonstrated clearly where to look for the real cause of the carbonization of caoutchouc.

Treatment with nitrobenzine alone:

Carbonaceous matters		17.22 p. c.	19.93 p. c.
Mineral matters	Calcium carbonate	20.78 p. c.	21.04 p. c.
	Lead carbonate / Lead oxide	40.27 p. c.	41.33 p. c.
	Lead sulphide / Lead sulphate	2.10 p. c.	1.00 p. c.
	Mineral matters	63.15 p. c.	63.87 p. c.

Treatment with mixture of chloroform and benzine:

Carbonaceous matters		traces.	
Mineral matters	Calcium carbonate	21.02 p. c.	21.11 p. c.
	Lead carbonate / Lead oxide	32.23 p. c.	31.56 p. c.
	Lead peroxide	9.97 p. c.	10.05 p. c.
	Lead sulphide / Lead sulphate	1.05 p. c.	0.88 p. c.
	Mineral matters	64.26 p. c.	63.60 p. c.

It will be seen that the mineral matter, which is isolated by treating the caoutchouc with the mixture of chloroform and nitrobenzine, contains a considerable quantity of lead peroxide, while at the same time almost free from carbon. On the contrary, the treatment of caoutchouc by nitrobenzine alone has furnished a high proportion of carbon and no peroxide of lead. It cannot be doubted, therefore, that at the boiling point of the nitrobenzine (208 deg.) the lead peroxide contained in the caoutchouc attacks it with formation of carbon; a reaction which, at the boiling point of the mixture of chloroform and nitrobenzine, does not take place. It is improbable that the lead peroxide found exists as such in the inorganic residue.

It is evident that it is generated by the minium (red lead) at the time of treating the residue with dilute nitric acid. Minium is often employed in the manufacture of vulcanized articles, especially when soft caoutchoucs are used. In this case minium exerts a hardening action, slightly oxidizing. Calculating in minium, the lead peroxide found in the second analysis, the composition of the inorganic residue must be expressed in the following numbers:

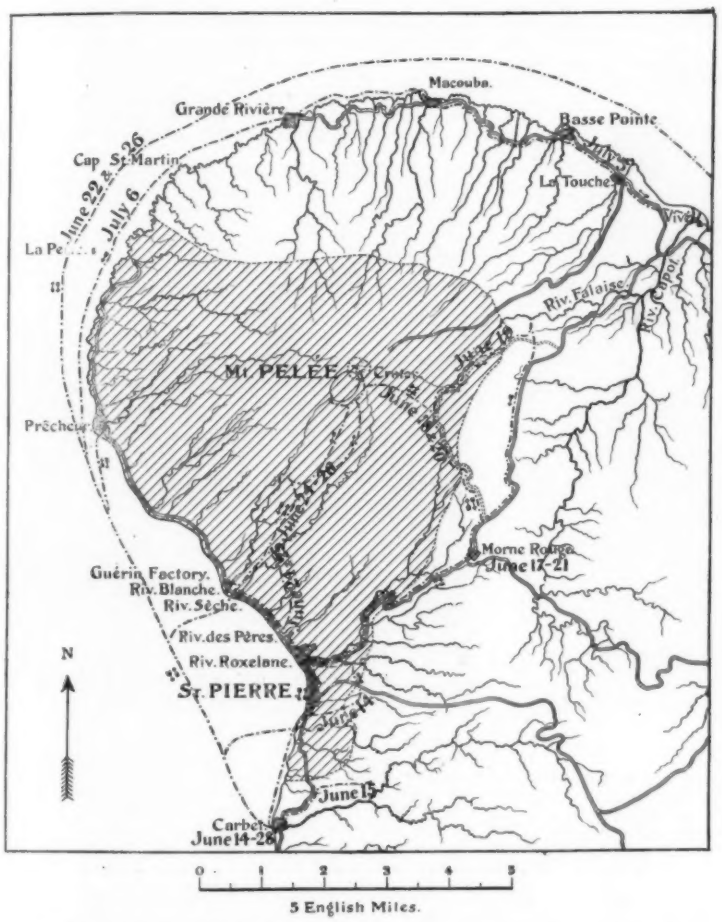
	(a)	(b)
Calcium carbonate	21.02 p. c.	21.11 p. c.
Lead carbonate / Lead oxide	32.23 p. c.	32.19 p. c.
Minium	10.27 p. c.	10.42 p. c.
Lead sulphide / Lead sulphate	1.05 p. c.	0.88 p. c.
	64.26 p. c.	63.60 p. c.

* Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from the German of M. Carl Otto Weber, in Zeitschrift für angewandte Chemie.

These numbers show that the caoutchouc which was employed contained about equal quantities of carbonate of lime, carbonate of lead, and minium.

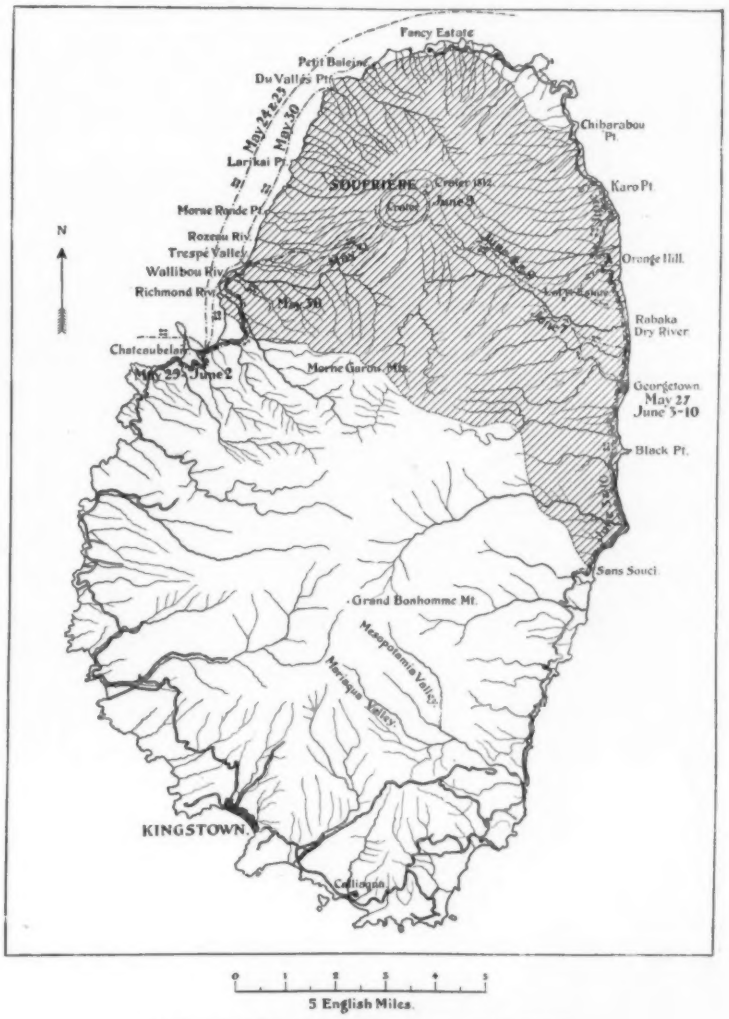
From a purely chemical view-point it would be extremely interesting to know what transformation caoutchouc undergoes by being treated with nitrobenzine alone, or in presence of chloroform. I have not yet had an occasion to study this question. As I have stated before caoutchouc exists no longer as such in the nitrobenzine solution. The result of this treatment must be a degradation of the molecule of caoutchouc.

It is known that caoutchouc, subjected to dry distillation, is almost entirely converted into hemiterpene, dipentene and polyterpene. We may infer that vulcanized caoutchouc undergoes a decomposition analogous to the effect of treatment with boiling nitrobenzine. The objection might here be raised that the non-vulcanized caoutchouc becomes almost viscous at the boiling point of nitrobenzine, while vulcanized caoutchouc hardly changes at this temperature. However, near 200 deg. C., caoutchouc begins to decompose, though slowly. It is probable, considering the nature of the products of the decomposition of caoutchouc, that isoprene, which constitutes about 15 per cent of the distilled portion, is not an immediate product of the decomposition, and that bodies with elevated molecular weight are first formed, which afterward give birth to citrene and isoprene. This view appears to be confirmed by the fact, which I have frequently observed in the dry distillation of different varieties of caoutchouc, that the slower the distillation, and consequently the lower the temperature, the smaller is the production of citrene and isoprene. Best results are obtained by introducing the caoutchouc in small quantities into the retort at red heat. I draw the conclusion from these facts that caoutchouc, under the influence of a high temperature, does not decompose into small molecules, but gives rise to products of elevated molecular weight. On the other hand, in the treatment of caoutchouc with nitrobenzine, that is, at a relatively low temperature, caoutchouc should furnish products of high molecular weight, perhaps a single product. If this were so, we would not only be able to determine the caoutchouc in manufactured articles, but we would also take an important step toward learning the size of the molecule of caoutchouc. I intend to continue my investigation in this direction.



MAP OF THE NORTHWESTERN PART OF THE ISLAND OF MARTINIQUE.

The cross-lined area shows approximately the area devastated by the eruptions from May to July, 1902; the area was greatly extended to the right of that shown by the eruption of August 30, 1902. The routes marked June 24, June 18, June 18 and 20, June 14 were those taken by Mr. Hovey.



MAP OF THE ISLAND OF ST. VINCENT.

The cross-lined area shows approximately the area devastated by the eruption.

THE VOLCANOES OF THE CARIBBEAN ISLANDS.*

APPEARANCE OF MONT PELÉ, MARTINIQUE, AND LA SOUFRIÈRE, ST. VINCENT, ONE YEAR AFTER THE GREAT ERUPTION.

By EDMUND OTIS HOVEY.

ALTHOUGH the principal islands of the Caribbees or Lesser Antilles have long been known to be of volcanic origin, and although eruptions from some of the old vents have taken place within historic time (Mont Pelé in 1762 and 1851, La Soufrière, St. Vincent, in 1718 and 1812, Dominica in 1880) not much attention seems to have been paid to the volcanology of the region prior to the great eruptions of Mont Pelé and the Soufrière which took place in May, 1902. World-wide interest in those eruptions was aroused by the great number of human beings swept out of existence in a moment of time, and particularly by the tragic destruction of the city of St. Pierre, Martinique, "the pearl of the Lesser Antilles." Contemporaneous with and subsequent to these Antillean eruptions, there occurred fresh and violent outbursts or increased activity in the volcanic centers of Guatemala, Mexico, Alaska, the Mediterranean, and other parts of the world, which made the year 1902 a memorable one in the annals of volcanology. In Martinique the eruptions of May 3, 5 and 8 were followed by noteworthy outbreaks on May 19, 20 and 26, June 6, July 9 and August 30, to say nothing of scores of smaller eruptions which under other circumstances would have been considered well deserving of mention. In St. Vincent the eruptions of May 6 and 7 were followed by great outbursts on May 18, September 3 and 4, and October 16, 1902, and March 22, 1903; but during the intervals, unlike Mont Pelé, La Soufrière was very quiet or entirely dormant.

In May, 1902, I was sent to Martinique and St. Vincent by the American Museum of Natural History to study and report upon the phenomena attending the eruptions. Seven weeks were spent upon the two islands during that expedition, and a preliminary report based upon the observations made then was issued by the Museum in October, 1902. In the winter and spring of 1903 I made a second expedition to the region at the request of the same institution, spending six weeks upon Martinique and St. Vincent and a nearly equal amount of time on the other principal volcanic islands of the group—St. Lucia, Dominica, Guadeloupe, Montserrat, Nevis, St. Christopher (St. Kitts), St. Eustatius (Statia), and Saba.

In Martinique the most striking change is the complete alteration of the skyline of Mont Pelé. Prior to the beginning of the present series of eruptions in April, 1902, the mountain was characterized by a great crater about half a mile across and sixteen hundred feet deep below the average level of the crater-rim. On the southwest side the rim was breached to the base by a great gash which was continued into the gorge of the Rivière Blanche. Montserrat and Nevis to-day stand as close analogues, on a smaller scale, of Mont Pelé before the eruptions. Within the great crater of Mont Pelé lay the small crater-lake known as L'Etang Sec, and from several openings around this lake began the eruption which has proven of such moment in the human history of the island. A cone or series of cones began forming at once; and my photographs and sketches, and those of other observers, made on May 21, 1902, show the existence of a comparatively small cone in the crater at the head of the gorge of the Blanche. Since that time the cone has grown until in March, 1903, the extreme top of the spine surmounting the main mass thereof was nearly 5,150 feet above tide, according to the determinations of the French geological commission.

On June 20, 1902, the inner cone had an irregular serrated rim surrounding a bowl-shaped depression, and the incomplete glimpses obtained seemed to indicate the existence at that time of a true crater in the top of the new cone. The growth of the spine and ribs of the cone has destroyed this crater, if it ever had any long-continued existence. Now, as then, steam issues with vigor from all parts of the cone, while minor explosions occur from the southwestern side at an elevation of apparently about four thousand feet above the sea, and from the northwestern side at a somewhat greater elevation.

Another striking change in Mont Pelé, to one who was familiar with the appearance of the mountain just after the eruptions began, is the filling of the gorge of the Rivière Blanche with calcined rocks and dust and ashes which have been poured out of the crater by the numerous eruptions. This was the gorge extending seaward from the great gash in the southwest side of the old crater, which determined the direction of the explosive volcanic blasts which swept over St. Pierre on May 8 and succeeding days. Now the lower portion of the gorge has been entirely obliterated, and the adjoining plateau elevated, while the upper and deeper portion near the crater has been almost filled by the ejecta. The line of this gorge is still the favorite direction of discharge of the volcano, and the great bowlders scattered thickly over the surface attest the violence of the explosion. Study of the material filling the gorge of the Blanche confirms the idea, formed last summer, that the volcanic dust, sand, and gravel which form by far the largest proportion of the beds in the gorge, issued from the cone or center of eruption in a dry or comparatively dry condition. The live steam permeating the mass caused the whole to act like a fluid, and rush down the gorge in a torrent which carried with it many large blocks of new and old lava. The solid particles were incandescent, and the steam rose in vast clouds as it was liberated from the flowing mass, so that the statement made by some observers, that streams of lava flowed from the crater, is not surprising. The liberated steam carried away into the atmosphere enormous quantities of the finest ash.

These dust-flows down the Rivière Blanche must not be confounded with the mud-flows down the same cañon. The mud-flow which overwhelmed the Usine Guérin seems to have been caused by the waters of the Etang Sec breaking through a temporary dam formed by new ash from the western vents within the crater, but succeeding mud-flows have been caused by the rain-soaked dust and ash on the inner slopes of the great crater and on the remainder of the drainage-basin of the Blanche descending in terrible avalanches. The mud-flows and mud-torrents which rushed down the gorges of the Sèche, Prêcheur, Grande, Macouba, Basse Pointe and Falaise rivers originated in large part from rain soaking the dust and ash on the upper slopes of the mountain beyond the point of equilibrium. The mud-flows when dry are hard and compact, and some of them are black or nearly so; the dust-flows are very light gray in color, have a calcined appearance, and are so soft and loose that one sinks in them to the knees. Water, however, will cement together the surface of a dust-flow, forming a crust over it. Mud-

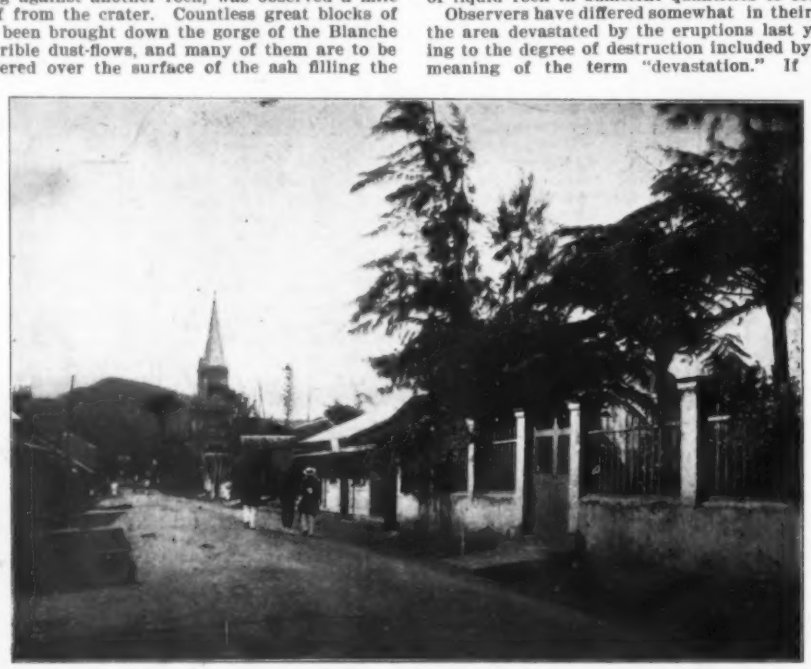
* The illustrations are from photographs by the author.

flows, especially where their motion is comparatively slow, show a surface wrinkled transversely to the direction of flow, while dust-flows do not present such a phenomenon.

Enormous masses of rock lie scattered about along the middle altitudes of the Sèche-Blanche plateau,

ERUPTION OF MT. PELÉ JULY 6, 1902.

where they were hurled by the eruptions. Some of these were broken into many fragments through striking on other rocks, while others landed in ash and were not even cracked. One mass forty feet across, but broken by striking against another rock, was observed a mile and a half from the crater. Countless great blocks of lava have been brought down the gorge of the Blanche by the terrible dust-flows, and many of them are to be seen scattered over the surface of the ash filling the



STREET IN MORNE ROUGE, MT. PELÉ, PRIOR TO THE ERUPTION.

From a photograph by Phos.

gorge. On the summit and eastern side of the mountain, especially, "bread-crust bombs" are more numerous than they were in June, 1902. These bombs (of which there is a large series on exhibition in the American Museum of Natural History) are masses or

BROKEN EJECTED BLOCK ON SÈCHE-BLANCHE PLATEAU, SOUTHWEST SIDE OF MT. PELÉ, ONE AND ONE-HALF MILES FROM CRATER.

fragments of lava which have reached the air in a viscous or partly fluid condition. Sudden cooling in the atmosphere has caused the exterior to solidify into a crust of volcanic glass, which has shrunk and has cracked in all directions. In spite of the fresh lava forming the spine, the dikes in the new cone, and the numberless bombs, no *stream* of molten lava has issued from Mont Pelé during the present series of eruptions. This phenomenon is probably due to the great excess of water-vapor (steam) connected with the eruptions, as compared with the amount of liquid or pasty lava rising in the conduit or series of conduits. This has caused the outbursts to be violently explosive and has not permitted the quiet exudation of liquid rock in sufficient quantities to form streams.

Observers have differed somewhat in their estimate of the area devastated by the eruptions last year, according to the degree of destruction included by each in his meaning of the term "devastation." If we include

RUINS OF ST. PIERRE AFTER MONTHS OF ERUPTIONS BY MT. PELÉ.

View from Statue Notre Dame de la Garde, looking north.

all the area over which all vegetation was actually destroyed for the time being, not less than forty square miles was thus affected by the outbursts from May to August, 1902. Over a considerable portion of this district the roots were not killed; and, the ash having been washed off, vegetation is now asserting itself on

TERMINUS OF A MUD RUN AS IT ENTERS THE OCEAN AT BASSE POINTE, MARTINIQUE.

The débris covers the site of the principal portion of the village, and is ten to fifteen feet deep.

the bluffs immediately behind St. Pierre, along the south side of the Roxelane River to the outskirts of Morne Rouge, and throughout Ajoupa Bouillon. The land included within the "zone of annihilation," however, shows no sign of returning life, except along some of the bluffs facing away from the crater and in some other spots which were protected from the powerful volcanic blasts. This zone of total destruction forms a "V"-shaped area on the west side of the mountain, with the apex at the crater and the broad portion extending from a point half a mile south of St. Pierre to a point about half a mile north of Prêcheur; while it spreads in a somewhat circular fashion two or three miles down the eastern and southeastern slopes of Mt. Pelé, just touching Ajoupa, Bouillon and including most of Morne Rouge. As to St. Pierre itself, the general appearance of the city from a distance has not altered greatly since July, 1902; but at a near view one sees that much of the dust and fine ash has been washed away; that grass is growing in the streets and amid the ruins in soil that has been washed down from the surrounding bluffs, and that many walls which were

SAME STREET, MORNE ROUGE, AFTER THE ERUPTION OF AUGUST 30, 1902.

weak then have fallen to the ground. The iron bridge over the Roxelane has been destroyed. A great quantity of volcanic sand has been washed up on the beach by the ocean. The evidences of the wrecked ships in the roadstead have disappeared. Some excavation amid the ruined houses and shops, in search of articles of value, has been carried on under sanction of the government. Everything looks very ancient, and St. Pierre seems like a dead city of the past.

The great sugarcane fields in the northern and northeastern part of Martinique were little or not at all injured by the eruptions, and this season the sugar-mills were running as busily as if no disaster had visited the island. The valleys, however—those of the Capot (from the Falaise), Basse Pointe, Macouba and Grande rivers—still bear ample evidences of the terrible floods which traversed them at various times during the con-

tinuance of the great activity of the volcano. Large parts of the villages of Basse Pointe and Grande Rivière have been washed out to sea or buried under from ten to fifteen feet of sand, gravel and bowlders. The scourge of volcanic eruption more slowly than Martinique, because the coating of ash was greater and of heavier material. The area of complete devastation, as mapped last summer, extended on the west side of the island from Richmond River on the south to Windsor Forest on the north, while on the east the area extended from Georgetown on the South to Chibarabou Point on the north, an area of not less than forty-five square miles. The eruptions of September and October cast three inches of fresh ash into the town of Georgetown, has proven a most serious blow to the work doing there and elsewhere in the affected district. In general, upon the western side the coating of ash is heavy and compact, so that it is only where rills have cut through this bed and into the old soil beneath, that any vegetation has appeared. The most striking change in the appearance of the mountain since June, 1902, lies in the excavation by the Wallibou, Rabaka, and other rivers, of the tremendous deposits of ash formed in their valleys last May and added to subsequently. The gorge of the Wallibou, for instance, was filled in May with ashes to a depth of not less than sixty feet on an average; but since then it has been entirely cleared of ash for more than three miles from its mouth, and the bed of the stream now is nearly down to its old level, indicating the removal of not less than a hundred and fifty million cubic feet of ash. Here and there a heavy body of ash has been protected from the action of the

GENERAL VIEW OF LA SOUFRIÈRE, ST. VINCENT.

AN ERUPTION OF LA SOUFRIÈRE VOLCANO, ST. VINCENT, MARCH 3, 1903.

alluvial fan of each of these rivers was extended from two hundred to three hundred yards into the sea by the material brought by these floods; but since last September the surf has cut deeply into the new deposits, and the currents have spread the sand and gravel for miles along the coast.

One cannot safely make predictions regarding the future of a volcano. In March and April, 1903, Mt. Pelé was far less active than it was at the time of my departure from Martinique last July. The eruptions of January 25 and March 26, 1903, while they were sufficiently energetic to send the familiar cauliflower column of dust-laden steam to an altitude of three thousand, four hundred meters (11,150 feet) above the summit of the mountain, and to send the clouds of steam, dust, sand, and stones rolling with terrific velocity down the gorge

LA SOUFRIÈRE, ST. VINCENT.

TRAIL TO SUMMIT AT 1,500 FEET ELEVATION, SHOWING MUD-COVERED RIDGE WITH ALMOST UNAFFECTED COATING ON THE CREST.

LA SOUFRIÈRE.

SOUTHEASTERN PORTION OF INTERIOR OF CRATER. COLUMN OF STEAM RISES FROM LAKE IN BOTTOM. VIEW ILLUSTRATES ALTERNATION OF THE BEDS OF LAVA WITH THOSE OF TUFF IN THE MAKE-UP OF THE ISLAND.

LA SOUFRIÈRE.

SOUTHWESTERN SIDE. VALLEY OF THE WALLIBOU RIVER, SHOWING ASH-BEDS 50 TO 75 FEET THICK, AND A SECONDARY OR SUPERFICIAL OUTBURST OF STEAM.

of the Blanche to the sea, would have been passed over without special comment during the active days of the months from May 8 to August 30, 1902. The probability is that there were several, if not many, such eruptions during that period. I myself saw such outbursts on May 21, June 15, 24 and 26, 1902; and other observers in conversation have mentioned other dates.

ST. VINCENT.

The island of St. Vincent is recovering from her scourge of volcanic eruption more slowly than Martinique, because the coating of ash was greater and of heavier material. The area of complete devastation, as mapped last summer, extended on the west side of extended this area somewhat to the southward; but the damage wrought on the extension was temporary, and was not in evidence by March, the zone of extension being covered with vegetation and producing its crops. On the west the area devastated in May still is barren of vegetation; but on the east the sides of the great ravines show much verdure. The plateaus, however, show no sign of life. An attempt was made this spring to resuscitate the Mount Bentinck estate near Georgetown; but the eruption of March 22, which descending torrents; and in many of these much pent-up heat remains in the mass, which gives rise to secondary eruptions and even to dry dust-flows. Such a dust-flow took place during my visit in March, 1903, and spread a fan-shaped coat of loose dust, sand, and gravel, from one foot to six or eight feet in depth, over about an acre of the nearly flat river-bottom. Early in February of the present year the activity of the crater began to increase noticeably, and during the

LA SOUFRIÈRE.

SOUTHWESTERN SIDE. A PECULIAR SECONDARY OUTBURST OF STEAM IN THE WALLIBOU VALLEY. THIS SUPERFICIAL ERUPTION THREW A TEMPORARY DAM ACROSS THE RIVER AND CAUSED A MUD-FLOW.

WALLIBOU VALLEY.

VIEW FROM THE SAME SPOT IN SPRING OF 1903. SHOWING THE GORGE CUT OUT BY THE WATER.

VIEW SHOWING THE GREAT DEPTH OF THE ASH FILLING THE RIVER GORGE.

THE WAVY LINE NEAR THE TOP OF THE BLUFF SHOWS THE UPPER SURFACE OF THE BEDS DEPOSITED BY THE ERUPTIONS OF MAY, 1902; THE PORTION OF THE ASH ABOVE THAT LINE WAS DEPOSITED BY THE ERUPTION OF SEPTEMBER 3–4, 1902.

early part of March, the time of my second visit, it was more active than it was on May 31, and June 4 and 9, of last year, when I visited the rim with fellow geologists. On March 3 of this year, I stood again upon the edge of the crater, and obtained a perfect view of what is one of the grandest caldrons in existence. This time my companions were Prof. Lacroix, the French geologist, and Mme. Lacroix, Lieutenant Deville, of the French gunboat "Jouffroy," and Rev. Thomas Huckerby, of Chateaubelair. The general impression among local observers is that there has been considerable increase in the size of the crater, especially in the diameter of the top from east to west. My photographs showing the condition of the crater May 31, 1902, look so much like what one sees to-day, that it does not seem safe to assert that any great change has taken place since that date. The incessant landslides have certainly cut back the northern and northeastern walls to some extent. The "saddle" (a knife-edge ridge) between the great crater and the crater of 1812 has disappeared, probably having been cut away during the great outbursts of May, 1902; and the divide between the craters has been lowered by the action of the repeated landslides in the great crater. The depth seems to have increased considerably. On May 31, 1902, Dr. T. A. Jaggar, Jr., and I estimated the distance to the surface of the lake in the bottom of the crater, from the point on which we were standing, at sixteen hundred feet; while Mr. G. C. Curtis made it eighteen hundred feet. On March 3, 1903, I estimated the depth at two thousand feet below the same point. The conditions were more favorable to accurate observation on the later date, and the increase of two hundred or four hundred feet may be more apparent than real. Instrumental measurement was not practicable at the time.

While we were on the rim, March 3, several outbursts of great beauty and interest occurred. They issued at irregular intervals and with varying degrees of intensity from near the center of the mud lake in the bottom of the great pit-like crater. The history of each was about as follows: First, the escape of steam increased notably, leading to an upthrow of black mud. This fountain of black mud rose and fell for a few seconds, and then from within it came a column of brown, dust-laden steam, rushing upward with great velocity in the familiar cauliflower convolutions, until it stood hundreds and perhaps thousands of feet above our heads. While the column was rising many stones could be seen in it, looking like sky rockets, with the long trails of white steam which they left behind them. These stones pursued slightly divergent paths; but, although some of them attained our altitude, all fell back harmlessly within the crater. On our journey around the crater, however, Mr. Huckerby and I noticed many stones on the rim which evidently had been thrown out within a few days of our visit. Some of the blocks, indeed, were lying on the footprints of a party which had made the tour less than a fortnight before. Sometimes the eruption produced nothing more than the fountain of black mud. In the intervals between outbreaks there was boiling or bubbling at more than one point in the lake, but when the eruptions occurred all energy seemed to be confined to the vent near the center.

Rev. Thomas Huckerby, who has done more than any other resident of St. Vincent in the study of the volcano, writes me under date of May 6 that he made an ascent of the mountain on the preceding day, and found that the eruption of March 22, 1903, had left much fresh ash within the crater, narrowing the lower part of the pit considerably. He found that a small lake still existed in the extreme bottom, and that it was boiling furiously.

The depth of the 1812 crater before May 7, 1902, is given at five hundred feet; and the imperfect view of the interior of it, which Mr. G. C. Curtis and I obtained on June 9, 1902, seemed to justify the estimate. This crater has not participated in the present series of eruptions, but there are fumaroles in the rock-wall which forms its northeastern boundary. These fumaroles may be the outlets for the steam and other hot vapors from the still heated interior of the mass of hot cinders which was thrown into this crater from the great crater during the October eruption. Now the floor of the 1812 crater is 260 feet (aneroid measurement) below the highest point of its rim, so that, if the estimate of its former depth be correct, the deposit of new ash in the pit is 240 feet in thickness. This deposit consists mainly of the ejecta from the great outburst of October 16, 1902. Fumaroles exist in the southern rock-wall of the Larakai Valley, which leads from the western side of the crater; and it seems probable that these are connected with the deep-seated source of heat of the volcano.

The western or leeward side of the mountain still presents differences from the eastern or windward side. In May and June, 1902, the material coating the leeward slopes seemed finer in grain than that on the windward slopes. The leeward slopes, especially of the upper half of the mountain, were slippery with deep mud, while the coating on the windward side was much looser in texture and there was little of the cement-like mud below the summit plateau. The eruption of September, 1902, left on the leeward slopes a hard, gravelly surface on which there are countless cindery black bombs of all sizes up to eight or ten inches in diameter. The September eruption did not have much effect upon the windward side; but the material from the October eruption passed, for the most part, in that direction, without, however, changing the loose character of the coating on the slopes.

The questions of supreme importance to the inhabitants of Martinique and St. Vincent are: "Have the eruptions ceased? Is there any danger to be feared for the country beyond the present zones of devastation?" Unfortunately the first question cannot be answered, since there is no sure way of predicting a serious outbreak long in advance. Last fall certain French and American scientists predicted that Mont Pelé would suffer a heavy eruption on December 20. This prophecy was not fulfilled at all, nor was another, that La Soufrière would explode again in January. Mont Pelé has not had a great eruption since August 30, 1902; but La Soufrière had a very severe outburst on March 22, 1903. There seems, however, to be no real cause for alarm for the islands outside the present zones of devastation, since the destruction wrought last year appears to mark the limit of the present volcanic energy No predictions can be made for the other Caribbean islands, but there seems to be no ground for anxiety regarding their volcanoes; except as to Guadeloupe's Soufrière, the fumarole area of which seems to be spreading somewhat and to show slowly increasing activity.

MODERN VIEWS ON MATTER: THE REALIZATION OF A DREAM.*

By SIR WILLIAM CROOKES, F.R.S., etc.

FOR nearly a century men who devote themselves to science have been dreaming of atoms, molecules, ultramundane particles, and speculating as to the origin of matter; and now to-day they have got, so far as to admit the possibility of resolving the chemical elements into simpler forms of matter, or even of refining them altogether away into ethereal vibrations or electrical energy.

This dream has been essentially a British dream, and we have become speculative and imaginative to an audacious extent, almost belying our character of a purely practical nation. The notion of impenetrable mysteries has been dismissed. A mystery is a thing to be solved—and "man alone can master the impossible." There has been a vivid new start. Our physicists have remodeled their views as to the constitution of matter, and as to the complexity if not the actual decomposability of the chemical elements.

The earliest definite suggestion in the last century of the possible compound nature of the elements occurs in a lecture delivered in 1809 by Sir Humphry Davy at the Royal Institution ("Works of Sir Humphry Davy," vol. viii., p. 325). In that memorable lecture he speculated on the existence of some substance common to all the metals, and he averred that "if such generalizations should be supported by facts, a new, a simple, and a grand philosophy would be the result. From the combination of different quantities of two or three species of ponderable matter we might conceive all the diversity of material substances to owe their constitution."

Again, in 1811, he said (*loc. cit.*, viii., 330): "It will be useless to speculate upon the consequences of such an advancement in chemistry as that of the decomposition and composition of the metals. . . . It is the duty of a chemist to be bold in pursuit. He must not consider things as impracticable merely because they have not yet been effected. He must not regard them as unreasonable because they do not coincide with popular opinion. He must recollect how contrary knowledge sometimes is to what appears to be experience. . . . To inquire whether the metals be capable of being decomposed and composed is a grand object of true philosophy."

Davy first used the term "Radiant Matter" about 1809, but chiefly in connection with what is now called radiation. He also used the term in another sense, and the following passage in its clear forecast is prophetic of the modern electron (*loc. cit.*, vol. viii., p. 349): "If particles of gases were made to move in free space with an almost infinitely great velocity, i. e., to become radiant matter, they might produce the different species of rays, so distinguished by their peculiar effects."

In his lectures at the Royal Institution, in 1816, "On the General Properties of Matter," another prescient chemist, Faraday, used similar terms when he said: "If we conceive a change as far beyond vaporization as that is above fluidity, and then take into account also the proportional increased extent of alteration as the changes rise, we shall, perhaps, if we can form any conception at all, not fall far short of radiant matter; and as in the last conversion many qualities were lost, so here also many more would disappear." Again, in one of his early lectures he strikes a forward note: "At present we begin to feel impatient, and to wish for a new state of chemical elements. To decompose the metals, to reform them, and to realize the once absurd notion of transmutation, are the problems now given to the chemist for solution."

But Faraday was always remarkable for the boldness and originality with which he regarded generally accepted theories. In 1844 he said: "The view that physical chemistry necessarily takes of atoms is now very large and complicated; first many elementary atoms—next compound and complicated atoms. System within system, like the starry heavens, *may be right*—but may *be all wrong*."

A year later Faraday startled the world by a discovery to which he gave the title "On the Magnetization of Light and the Illumination of the Magnetic Lines of Force." For fifty years this title was misunderstood and was attributed to enthusiasm or confused ideas. But to-day we begin to see the full significance of the Faraday dream.

It was not till 1896 that Zeeman showed a spectrum line could be acted on by a magnetic field. A spectrum line is caused by motion of the electron acting on the ether, which can only move and be moved by the electron. A magnetic field resolves this motion into other component motions, some slower, others quicker, and thus causes a single line to split into others of greater and less refrangibility than the parent line.

In 1879, in a lecture I delivered before the British Association at Sheffield, it fell to my lot to revive "Radiant Matter" ("British Association Reports," Sheffield Meeting, 1879; Chemical News, vol. xl., p. 91; Phil. Trans. Roy. Soc., 1879, Part I., p. 585; Proc. Roy. Soc., 1880, No. 205, p. 469). I advanced the theory that in the phenomena of the vacuum tube at high exhaustions the particles constituting the cathode stream are not solid, nor liquid, nor gaseous, do not consist of atoms propelled through the tube and causing luminous, mechanic, or electric phenomena where they strike, "but that they consist of something much smaller than the atom—fragments of matter, ultra-atomic corpuscles, minute things, very much smaller, very much lighter than atoms—things which appear to be the foundation stones of which atoms are composed" (Sir O. Lodge, Nature, vol. lxvii., p. 451).

I further demonstrated that the physical properties of radiant matter are common to all matter at this low density—"Whether the gas originally under experiment be hydrogen, carbon dioxide, or atmospheric air, the phenomena of phosphorescence, shadows, magnetic deflection, etc., are identical." Here are my words written nearly a quarter of a century ago: "We have actually touched the border land where matter and force seem to merge into one another—the shadowy realm between the known and unknown ("Matter is but a mode of motion," Proc. Roy. Soc., No. 205, p. 472). I venture to think that the greatest scientific problems of the future will find their solution in this borderland, and even beyond; here, it seems to me, lie ultimate realities, subtle, far-reaching, wonderful."

It was not till 1881 that J. J. Thomson established the basis of the electro-dynamic theory. In a very remarkable memoir in the Philosophical Magazine he explained the phosphorescence of glass under the influence of the cathode stream by the nearly abrupt changes in the magnetic field arising from the sudden stoppage of the cathode particles.

The now generally accepted view that our chemical elements have been formed from one primordial substance was advocated in 1888 by me when president of the Chemical Society, in connection with a theory of the Genesis of the Elements (Pres. Address to Chem. Soc., March 28, 1888). I spoke of "an infinite number of immeasurably small ultimate—or, rather, ultimatissimate—particles gradually accreting out of the formless mist, and moving with inconceivable velocity in all directions."

Pondering on some of the properties of the rare elements, I strove to show that the elementary atoms themselves might not be the same now as when first generated—that the primary motions which constitute the existence of the atom might slowly be changing, and even the secondary motions which produce all the effects we can observe—heat, chemic, electric, and so forth—might in a slight degree be affected; and I showed the probability that the atoms of the chemical elements were not eternal in existence, but shared with the rest of creation the attributes of decay and death.

The same idea was expanded at a lecture I delivered at the Royal Institution in 1887, when it was suggested that the atomic weights were not invariable quantities.

I might quote Mr. Herbert Spencer, Sir Benjamin Brodie, Prof. Graham, Sir George Stokes, Sir William Thomson (now Lord Kelvin), Sir Norman Lockyer, Dr. Gladstone, and many other English *savans* to show that the notion—not necessarily of the decomposability but at any rate of the complexity of our supposed elements—has long been "in the air" of science, waiting to take more definite development. Our minds are gradually getting accustomed to the idea of the genesis of the elements, and many of us are straining for the first glimpse of the resolution of the chemical atom. We are eager to enter the portal of the mysterious region too readily ticketed "Unknown and Unknowable."

Another phase of the dream now demands attention. I come to the earlier glimpses of the electric theory of matter.

Passing over the vaguer speculations of Faraday and the more positive speculations of Sir William Thomson (now Lord Kelvin), one of the earliest definite statements of this theory is given in an article in the Fortnightly Review for June, 1875, by W. K. Clifford—a man who in common with other pioneers shared that "noblest misfortune of being born before his time." "There is great reason to believe," said Clifford, "that every material atom carries upon it a small electric current, *if it does not wholly consist of this current*."

In 1886, when president of the Chemical Section of the British Association, in a speculation on the origin of matter, I drew a picture of the gradual formation of the chemical elements by the workings of three forms of energy—electricity, chemism, and temperature— on the "formless mist" (protyle*), wherein all matter was in the pre-atomic state—potential rather than actual. In this scheme the chemical elements owe their stability to their being the outcome of a struggle for existence—a Darwinian development by chemical evolution—a survival of the most stable. Those of lowest atomic weight would first be formed, then those of intermediate weight, and finally the elements having the highest atomic weights, such as thorium and uranium. I spoke of the "dissociation point" of the elements. "What comes after uranium?" I asked. And I answered back—"The result of the next step will be . . . the formation of . . . compounds the dissociation of which is not beyond the powers of our terrestrial sources of heat." A dream less than twenty years ago, but a dream which daily draws nearer to entire and vivid fulfillment. I will presently show you that radium, the next after uranium, does actually and spontaneously dissociate.

The idea of units or atoms of electricity—an idea hitherto floating intangibly like the helium in the sun—can now be brought to earth and submitted to the test of experiment.† Faraday, W. Weber, Laurentz,

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* An Address delivered before the Congress of Applied Chemistry at Berlin, June 5, 1903.

* We require a word, analogous to protoplasm, to express the idea of the original primal matter existing before the evolution of the chemical elements. The word I venture to use is composed of $\pi\rho\acute{\omega}\tau$ (earlier than) and $\upsilon\lambda\eta$ (the stuff of which things are made).

† "The equivalent weights of bodies are simply those quantities of them which contain equal quantities of electricity; . . . it being the electricity which determines the equivalent number, because it determines the combining force. Or, if we adopt the atomic theory or phraseology, then the atoms of bodies which are equivalents to each other in their ordinary chemical action, have equal quantities of electricity naturally associated with them."—Faraday's Experimental Researches in Electricity," par. 860, Jan., 1834.

"This definite quantity of electricity we shall call the molecular charge. If it were known it would be the most natural unit of electricity.'—Clerk Maxwell's "Treatise on Electricity and Magnetism," First Edition, vol. I., 1873, p. 311.

"Nature presents us with a single definite quantity of electricity. . . . For each chemical bond which is ruptured within an electrolyte a certain quantity of electricity traverses the electrolyte, which is the same in all cases."—G. Johnstone Stoney, "On the Physical Units of Nature," British Association Meeting, Section A, 1874.

"The same definite quantity of either positive or negative electricity moves always with each univalent ion, or with every unit of affinity of a multivalent ion."—Helmholtz, Faraday Lecture, 1881.

"Every monad atom has associated with it a certain definite quantity of electricity; every dyad has twice this quantity associated with it; every triad three times as much, and so on."—O. Lodge, "On Electrolysis," British Association Report, 1885.

Gauss, Zöllner, Hertz, Helmholtz, Johnstone Stoney, Sir Oliver Lodge, have all contributed to develop the idea—originally due to Weber—which took concrete form when Stoney showed that Faraday's law of electrolysis involved the existence of a definite charge of electricity associated with the ions of matter. This definite charge he called an electron. It was not till some time after the name had been given that electrons were found to be capable of existing separately.

In 1891, in my inaugural address as president of the Institution of Electrical Engineers,* I showed that the stream of cathode rays near the negative pole was always negatively electrified, the other contents of the tube being positively electrified, and I explained that "the division of the molecule into groups of electro-positive and electro-negative atoms is necessary for a consistent explanation of the genesis of the elements." In a vacuum tube the negative pole is the entrance and the positive pole the exit for electrons. Falling on a phosphorescent body, yttria, for instance—a collection of Hertz molecular resonators—the electrons excite vibrations of, say, 550 billion times a second, producing ether waves of the approximate length of 5.75 ten-millionths of a millimeter, and occasioning in the eye the sensation of citron-colored light. If, however, the electrons dash against a heavy metal, they produce ether waves of a far higher frequency than light, and are not continuous vibrations, but, according to Sir George Stokes, simple shocks or solitary impulses; more like discordant shouts as compared with musical notes.

During that address an experiment was shown which went far to prove the dissociation of silver into electrons and positive atoms.† A silver pole was used, and near it in front was a sheet of mica with a hole in its center. The vacuum was very high, and when the poles were connected with the coil, the silver being negative, electrons shot from it in all directions, and passing through the hole in the mica screen, formed a bright phosphorescent patch on the opposite side of the bulb. The action of the coil was continued for some hours, to volatilize a certain portion of the silver. Silver was seen to be deposited on the mica screen only in the immediate neighborhood of the pole; the far end of the bulb, which had been glowing for hours from the impact of electrons, being free from silver deposit. Here, then, are two simultaneous actions. Electrons, or radiant matter shot from the negative pole, caused the glass against which they struck to glow with phosphorescent light. Simultaneously, the heavy positive ions of silver, freed from the negative electrons, and under the influence of the electrical stress, likewise flew off and were deposited in the metallic state near the pole. The ions of metal thus deposited in all cases showed positive electrification (Proc. Roy. Soc., vol. lxix., p. 421).

In the years 1893-4-5 a sudden impulse was given to electric vacuum work by the publication in Germany of the remarkable results obtained by Lenard and Röntgen, who showed that the phenomena inside the vacuum tube were surpassed in interest by what took place outside. It is not too much to say that from this date what had been a scientific conjecture became a sober reality.

One important advance in theoretic knowledge has been obtained by Dewar, the successor of Faraday in the classic laboratories of the Royal Institution. Soon after Röntgen's discovery Dewar found that the relative opacity to the Röntgen rays was in proportion to the atomic weights of bodies, and he was the first to apply this principle to settling a debated point in connection with argon. Argon is relatively more opaque to the Röntgen rays than either oxygen, nitrogen, or sodium, and from this Dewar inferred that the atomic weight of argon was twice its density relative to hydrogen. In the light of to-day's researches on the constitution of atoms, it is impossible to overestimate the importance of this discovery.

In 1896 Becquerel, pursuing the masterly work on phosphorescence inaugurated by his illustrious father, showed that the salts of uranium constantly emit emanations which have the power of penetrating opaque substances and of affecting a photographic plate in total darkness, and of discharging an electrometer. In some respects these emanations, known as Becquerel rays, behave like rays of light, but they also resemble Röntgen rays. Their real character has only recently been ascertained, and even now there is much that is obscure and provisional in the explanation of their constitution and action.

Following closely upon Becquerel's work came the brilliant researches of M. and Mdme. Curie, on the radio-activity of bodies accompanying uranium.

Hitherto I have been recounting isolated instances of scientific speculation with apparently little relation to one another. The existence of matter in an ultra-gaseous state; material particles smaller than atoms; the existence of electrical atoms or electrons; the constitution of Röntgen rays and their passage through opaque bodies; the emanations from uranium; the dissociation of the elements—all these isolated hypotheses are now focused and welded into one harmonious theory by the discovery of radium.

"Often do the spirits
Of great events stride on before the events,
And in to-day already walks to-morrow."

No new discovery is ever made without its influence ramifying in all directions and explaining much that before had been mystifying. Certainly no discovery of modern times has had such wide-embracing consequences, and thrown such a flood of light on broad regions of hitherto inexplicable phenomena, as this discovery of M. and Mdme. Curie and M. Bémont, who patiently and laboriously plodded along a road bristling with difficulties almost insuperable, to others who, like myself, have toiled in similar labyrinths of research. The crowning point of these labors is radium.

Let me briefly recount some of the properties of radium, and show how it reduces speculations and dreams, apparently impossible of proof, to a concrete form.

Radium is a metal of the calcium, strontium, and barium group. Its atomic weight according to C. Runge and J. Precht is probably about 258. In this case it occupies the third place below barium in my lemniscate spiral scheme of the elements, two unoccupied gaps intervening (Proc. Roy. Soc., vol. lxiii., p. 408).

The spectrum of radium has several well-defined lines; these I have photographed and have also measured their wave-lengths. Two especially are strong and characteristic. One at wave-length 3649.71 and the other at wave-length 3814.58. These lines enable radium to be detected spectroscopically.

The most striking property of radium is its power to pour out torrents of emanations bearing a certain resemblance to Röntgen rays, but differing in important points.

The emanations of radium cause soda-glass to assume a violet color, and they produce many chemical changes. Their physiological action is strong, a few milligrammes brought near the skin in a few hours producing a wound difficult to heal.

The emanations from radium are of three kinds. One set is the same as the cathode stream, now identified with free electrons—atoms of electricity projected into space apart from gross matter—identical with "matter in the fourth or ultra-gaseous state." Kelvin's "satellites," Thomson's "corpuscles" or "particles;" Lodge's "disembodied ionic charges, retaining individuality and identity." These electrons are neither ether waves, nor a form of energy, but substance possessing inertia (probably electric). Liberated electrons are exceedingly penetrating. They will discharge an electroscope when the radium is ten feet or more away, and will affect a photographic plate, through five or six mm. of lead and several inches of wood or aluminium. They are not readily filtered out by cotton-wool; they do not behave as a gas, i. e., they have not properties dependent on inter-collisions, mean free path, etc.; they act more like a fog or mist, are mobile and carried about by a current of air to which they give temporary conducting powers, clinging to positively electrified bodies and thereby losing mobility and diffusing on the walls of the containing vessel if left quiet.

Electrons are deviable in a magnetic field. They are shot from radium with a velocity of about one-tenth that of light, but are gradually obstructed by collisions with air atoms, so that some become much slowed, and then are what I formerly called loose and erratic particles, which diffuse about in the air, and give it temporary conducting powers. These can turn corners, can be concentrated by mica cones into a bundle and then produce phosphorescence.

Another set of emanations from radium are not affected by an ordinarily powerful magnetic field, and are incapable even of passing through thin material obstructions. These emanations have about one thousand times the energy of those radiated by the deflectable particles. They render air a conductor and act strongly on a photographic plate. Their mass is enormous in comparison with that of the electrons, and their velocity is probably as great when they leave the radium, but, in consequence of their greater mass, they are less deflected by the magnet, are easily obstructed by obstacles, and are sooner brought to rest by collisions with air atoms. The Hon. R. B. Strutt (Phil. Trans. R. S., A, 1901, vol. excvi., p. 525) was the first to affirm that these non-deflectable rays are the positive ions moving in a stream from the radio-active body.

Rutherford has shown that these emanations are slightly affected in a very powerful magnetic field, but in an opposite direction to the negative electrons. They are therefore proved to be positively charged bodies moving with great velocity. For the first time Rutherford has measured their speed and mass, and he shows they are ions of matter moving with a speed of the order of that light.

There is also a third kind of emanation produced by radium. Besides the highly penetrating rays deflected by a magnet, there are very penetrating rays not at all affected by magnetism. These accompany the previous emanations, and are Röntgen rays—ether vibrations—produced as secondary phenomena by the sudden arrest of velocity of the electrons by solid matter, producing a series of Stokesian "pulses" or explosive ether waves shot into space.

Many lines of argument and research tending toward the same point give trustworthy data by which to calculate the masses and velocities of these different particles. I must deal with big figures, but big and little are relative, and are only of importance in relation to the limitations of our senses. I will take as the standard the atom of hydrogen gas—the smallest material body hitherto recognized. The mass of an electron is 1/700th of an atom of hydrogen, or 3×10^{-26} grm. according to J. J. Thomson, and its velocity is 2×10^{9} centimeters per second, or two-thirds that of light. The kinetic energy per milligramme is 10^{17} ergs, about three and one-half million foot-tons. Becquerel has calculated that one square centimeter of radio-active surface would radiate into space one gramme of matter in one billion years.

The positively electrified masses or ions are enormously great in comparison with the size of the electron. Sir Oliver Lodge illustrates it thus: If we imagine an ordinary-sized church to be an atom of hydrogen, the electrons constituting it will be represented by about 700 grains of sand each the size of an ordinary full-stop (350 positive and 350 negative) dashing in all directions inside, or, according to Lord Kelvin, rotating with inconceivable velocity. Put in another way; the sun's diameter is about one and a half million kilometers, and that of the smallest planetoid about 24 kilometers. If an atom of hydrogen be magnified to the size of the sun, an electron will be about two-thirds the diameter of the planetoid.

The extreme minuteness and sparseness of the electrons in the atom account for their penetration. While the more massive ions are stopped by intercollisions in passing among atoms, so that they are almost completely arrested by the thinnest sheet of matter, electrons will pass almost unobstructed through ordinary opaque bodies.

The action of these emanations on phosphorescent screens is different. The electrons strongly affect a screen of barium platinocyanide, but only slightly one of Sidot's zinc sulphide. On the other hand, the heavy, massive, non-deflectable positive ions affect the zinc sulphide strongly, and the barium platinocyanide screen in a much less degree.

Both Röntgen rays and electrons act on a photographic plate and produce images of metal and other substances inclosed in wood and leather, and throw shadows of bodies on a barium platinocyanide screen. Electrons are much less penetrating than Röntgen rays, and will not, for instance, show easily the bones of the hand. A photograph of a closed case of instruments is taken by radium emanations in three days, and by Röntgen rays in three minutes. The resemblance between the two pictures is slight, and the differences great.

The power with which radium emanations are endowed of discharging electrified bodies is due to the ionization of the gas through which they pass. This can be effected in many other ways; thus, ionization is communicated to gases faintly by the splashing of water, by flames and red-hot bodies, by ultra-violet light falling on negatively electrified metals, and strongly by the passage of Röntgen rays.

According to Sir Oliver Lodge's electronic theory of matter, a chemical atom or ion has a few extra negative electrons in addition to the ordinary neutral atom, and if these negative electrons are removed it thereby becomes positively charged. The free electron portion of the atom is small in comparison with the main bulk, in the proportion in hydrogen of about 1 to 700. The negative charge consists of super-added or unbalanced electrons—one, two, three, etc., according to the chemical valency of the body—whereas the main bulk of the atom consists of paired groups, equal positive and negative. As soon as the excess electrons are removed, the rest of the atom, or ion, acts as a massive positively charged body, hanging tightly together. In a high vacuum the induction spark tears the components of a rarefied gas apart; the positively charged ions, having great comparative density are soon slowed down by collisions, while the electrons are driven from the negative pole with an enormous velocity depending on the initial electromotive force and the pressure of gas inside the tube, but approaching, at the highest exhaustions, half that of light.

After leaving the negative pole the electrons meet with a certain resistance, in a slight degree by physical collisions, but principally by reunion with the positive ions.

Since the discovery of radium and the identification of one set of its emanations with the cathode stream or radiant matter of the vacuum tube, speculation and experiment have gone hand in hand, and the two-fluid theory of electricity is gradually replaced by the original one-fluid theory of Franklin. On the two-fluid theory, the electrons constitute free negative electricity, and the rest of the chemical atom is charged positively, although a free positive electron is not known. It seems to me simpler to use the original one-fluid theory of Franklin, and to say that the electron is the atom or unit of electricity. Fleming uses the word "co-electrons" to express the heavy positive ion after separation from the negative electron: "We can no more," he says, "have anything which can be called electricity apart from corpuscles than we can have momentum apart from moving matter." A so-called negatively charged chemical atom is one having a surplus of electrons, the number depending on the valency, while a positive ion is one having a deficiency of electrons. Differences of electrical charge may thus be likened to debits and credits in one's banking account, the electrons acting as current coin of the realm. On this view only the electron exists; it is the atom of electricity, and the words positive and negative, signifying excess and defect of electrons, are only used for convenience of old-fashioned nomenclature.

The electron theory fits and luminously explains Ampère's idea that magnetism is due to a rotating current of electricity round each atom of iron; and following these definite views of the existence of free electrons, has arisen the electronic theory of matter. It is recognized that electrons have the one property which has been regarded as inseparable from matter—nay, almost impossible to separate from our conception of matter—I mean inertia. Now, in that remarkable paper of J. J. Thomson's, published in 1881, he developed the idea of electric inertia (self-induction) as a reality due to a moving charge. The electron therefore appears only as apparent mass by reason of its electro-dynamic properties, and if we consider all forms of matter to be merely congeries of electrons, the inertia of matter would be explained without any material basis. On this view the electron would be the "protyle" of 1886, whose different groupings cause the Genesis of the Elements.

There is one more property of the emanations of radium to bring before your notice. I have shown that the electrons produce phosphorescence of a sensitive screen of barium platinocyanide, and the positive ions of radium produce phosphorescence of a screen of zinc blende.

If a few minute grains of radium salt fall on the zinc sulphide screen the surface is immediately dotted with brilliant specks of green light. In a dark room, under a microscope with a 2-3-inch objective, each luminous spot shows a dull center surrounded by a diffused luminous halo. Outside the halo the dark surface of the screen scintillates with sparks of light. No two flashes succeed on the same spot, but are scattered over the surface, coming and going instantaneously, no movement of translation being seen.

If a solid piece of radium salt is brought near the screen, and the surface examined with a pocket lens magnifying about 20 diameters, scintillating spots are sparsely scattered over the surface. Bringing the radium nearer the screen the scintillations become more numerous and brighter, until when close together the flashes follow so quickly that the surface looks like a turbulent luminous sea. When the scintillating points are few there is no visible residual phosphorescence, and the successive sparks appear "atoms of intensest light," like stars on a black sky. What to the naked eye seems like a uniform "milky way," under

* "Electricity in Transits: from Plenum to Vacuum" (Journ. Inst. Electrical Engineers, vol. xx., p. 10, January 15, 1891).

† In describing the experiment, one of fundamental importance, modern terms are employed.

the lens becomes a multitude of stellar points, flashing over the whole surface.

"Polonium" basic nitrate, actinium, and radio-active platinum produce a similar effect on the screen, but the scintillations are fewer. In a vacuum the scintillations are as bright as in air, and being due to interatomic motion they are not affected by extremes of low temperature; in liquid hydrogen they are as brilliant as at the ordinary temperature.

A convenient way to show these scintillations is to fit the blende screen at the end of a brass tube with a speck of radium salt in front about a millimeter off, and to have a lens at the other end. I propose to call this little instrument the "spinthariscope," from the Greek word σπινθαρίς, a scintillation.

It is difficult to estimate the number of flashes of light per second. With the radium about five centimeters off the screen the flashes are barely detectable, not more than one or two per second. As the distance of the radium diminishes, the flashes become more frequent, until at one or two centimeters they are too numerous to count, although it is evident this is not of an order of magnitude inconceivably great.

Practically the whole of the luminosity on the blende screen, whether due to radium or "polonium," is occasioned by emanations which will not penetrate card. These are the emanations which cause the scintillations, and the reason why they are distinct on the blende and feeble on the platinocyanide screen, is that with the latter the sparks are seen on a luminous ground of general phosphorescence which renders the eye less able to see the scintillations.

It is probable that in these phenomena we actually witness the bombardment of the screen by the positive ions hurled off by radium with a velocity of the order of that of light. Each particle is rendered apparent only by the enormous extent of lateral disturbance produced by its impact on the sensitive surface, just as individual drops of rain falling on a still pool are not seen as such, but by reason of the splash they make on impact, and the ripples and waves they produce in ever-widening circles.

Indulging in a "Scientific Use of the Imagination," and pushing the hypothesis of the electronic constitution of Matter to what I consider its logical limit, we may be, in fact, witnessing a spontaneous dissociation of radium—and we begin to doubt the permanent stability of matter. The chemical atom may be actually suffering a katabolic transformation; but at so slow a rate that supposing a million atoms fly off every second, it would take a century for weight to diminish by one milligramme.

It must never be forgotten that theories are only useful so long as they admit of the harmonious correlation of facts into a reasonable system. Directly a fact refuses to be pigeon-holed and will not be explained on theoretic grounds, the theory must go, or it must be revised to admit the new fact. The nineteenth century saw the birth of new views of atoms, electricity, and ether. Our views to-day of the constitution of matter may appear satisfactory to us, but how will it be at the close of the twentieth century? Are we not incessantly learning the lesson that our researches have only a provisional value? A hundred years hence shall we acquiesce in the resolution of the material universe into a swarm of rushing electrons?

This fatal quality of atomic dissociation appears to be universal and operates whenever we brush a piece of glass with silk; it works in the sunshine and raindrops, and in the lightnings and flame; it prevails in the waterfall and the stormy sea. And although the whole range of human experience is all too short to afford a parallax whereby the date of the extinction of Matter can be calculated, Protyle, the "formless mist," once again may reign supreme, and the hour hand of eternity will have completed one revolution.

HERTZIAN WAVE TELEGRAPHY.

DR. FLEMING'S SECOND PAPER.

DR. FLEMING commenced his second lecture by saying that the former lecture was devoted to the theory of the radiator or "aerial," and that the present one would deal with transmitting arrangements and transmitters.

Referring to the diagram of the siren and electric oscillator, he said that he would push further the analogy which he explained in the former lecture. Last time he had dealt with the pipe in which the vibrations of the siren were produced, and with the wire which served a like purpose for the electric oscillator; he would now turn to two other analogous features, which were an air-compressing pump and an induction coil. In wireless telegraphy the source of power was either an induction coil or an alternating-current transformer. A battery would not give sufficient pressure for the purpose. It was customary to use 10-inch coils—that is, coils which would give a spark in air of a length of 10 inches. He then threw upon the screen a section of such a coil, rapidly explaining its construction, and laying stress on the fact that the secondary had to be very carefully insulated, so that wires having large differences of electromotive force should not be adjacent to each other. The coil which he illustrated had a length of 200 yards of wire in the primary and 17 miles in the secondary. There was a current in the secondary only when the current in the primary was either stopping or starting, and hence the construction of the interrupter, which stopped and started the primary current, was a matter of very great importance. The most usual form of interrupter was known as the "hammer break," and consisted of a piece of iron which was attracted by the core of the coil, and in moving broke the primary circuit; it then fell back and renewed the circuit. Such breaks, however, were far from being efficient, and new forms had been devised. It was customary also to put a condenser in parallel with the break. This arrangement still persisted, because instrument-makers were a conservative race, and made their coils now in the same way as they did twenty years ago. Messrs. Newton & Co., of Fleet Street, have, however, we understand, recently designed for the Admiralty a form of induction coil specially adapted for wireless telegraphy.

Better devices had been produced in Germany, and there were several forms of break originating there which gave good results. It was Fizeau who, in 1853, introduced the condenser, as he found its employment increased the electromotive force at the terminals of the secondary. Lord Rayleigh, however, had shown that if the break were sufficiently sudden, the condenser was not needed. Prof. Trowbridge had also devised a break in which a platinum wire was dipped into, and raised out of, an acid, and this break did not need a condenser. Several forms of mercury break had been devised, more particularly for use with Röntgen ray apparatus. In the Mackenzie-Davidson break a paddle, driven by an electric motor, worked in a bath of mercury, and by churning up the mercury caused interruptions in the current. An improvement on this, known as the mercury turbine break, had been devised by Max Levy. In this there was a quantity of mercury contained in an open-mouthed cylinder, in which there rotated a paddle wheel acting as a centrifugal pump. This wheel drove the mercury over the top of the cylinder, and projected it against an electrode. Around the cylinder there rotated a second cylinder of non-conducting material, the lower edge of which was serrated. The teeth of these serrations masked the electrode, and cut off the steam of mercury, while the spaces between the teeth allowed the mercury to pass. The mercury itself formed one electrode of the apparatus, and consequently the circuit was alternately broken and made. By varying the speed of the motor, it was possible to regulate the number of breaks per second, and also the interval between them, and by this device the working of the coil could be largely controlled. At the maximum speed of 700 breaks per second the spark was thin and crackling, while at the lower speeds—of less than 100 per second—the spark grew full and fat, and less noisy. An interrupter based on these principles was constructed by the Allgemeine Elektricitäts Gesellschaft. This interrupter required the use of several pounds of mercury, and to avoid this another form was constructed, in which a disk, provided with copper segments, ran under carbon brushes, being driven from a motor whose speed was under complete control.

In 1899 Wehnelt brought out an electrolytic break, in which a lead plate immersed in dilute acid formed one electrode, and a platinum wire passing through the bottom of a porcelain tube, the other electrode. In a circuit containing inductance, the current passed intermittently from the platinum to the lead, the interruptions being at the rate of thousands per second, and being variable according to the protrusion of the platinum wire. There had been much discussion as to the theory of this apparatus, but he had not had time to go into that matter. It was found to work best at a difference of potential of 60 to 80 volts, and gave from 100 to 2,000 interruptions per second. The frequency, however, was not under very exact control. A modification of the apparatus had been devised by Caldwell, and is shown in Fig. 2 annexed. Here the electrodes are two lead plates, one of which is contained in a tube perforated with several holes. A further modification of this was devised by Campbell-Swinton. Here, as shown in Fig. 3, the tube had only one aperture at the bottom, and this could be more or less closed by a pointed glass rod, this rod forming the means of adjustment. In such apparatus, however, it was not possible to alter the frequency without at the same time changing the current, and for wireless telegraphy such breaks were not of much importance.

The lecturer then turned to describe the requisites of a good break. The function of the induction coil was to charge a condenser, and this made a great difference in its action; a coil which would give a 10-inch spark in air would, when joined to a condenser, only give a spark of a few millimeters. The lecturer joined on to a coil which he had on the table a capacity of 1-100 microfarad, and showed that he could not get a fraction of the electromotive force which the coil had previously given. By means of a diagram, Dr. Fleming explained that when the current was set up in the primary wire of a coil there was a sudden rush of current in the secondary, which lasted only so long as the current in the primary was increasing. Then so long as the primary current was uniform there was no current in the secondary, while when the primary current was dying away to nothing, on account of the break of the circuit, there was a sudden rise of electromotive force—a generation of current—in the secondary. The more quickly the current in the primary was stopped, the greater was the electromotive force in the secondary, and the shorter the time that the current flowed therein. As an analogy to help his audience to understand how important it was that the break of current should be as instantaneous as possible, Dr. Fleming adduced the case of a number of cisterns, each capable of holding about a bucketful, but some narrow and others wide. If a bucketful of water were poured into a narrow cistern, it rose to a considerable height and produced comparatively large pressure at the bottom; while if the cistern were broad, the depth of water was small and the pressure little. Now a condenser charged by a coil was like a cistern, and if it were of large capacity, the pressure in it was only small; while if it were of small capacity the pressure was correspondingly large. Unfortunately, makers of coils could never tell how they would behave when connected to a capacity of a certain size. But for aerial telegraphy it was absolutely necessary to have a capacity in order to get a store of energy, and also a coil that was capable of supplying electricity fast. Fig. 4 shows results plotted from the terminal voltage of a condenser of capacity C, charged through a resistance R, C being measured in microfarads and R in megohms. This diagram showed that the coil was only capable to charge the condenser up to 60 per cent of its capacity in one second, and that it needed six or seven seconds to complete the charge. Every condenser had a time constant, which was given by the formula below.

The period of an electric oscillation in a circuit of inductance L centimeters and capacity C microfarads is:

$$T=\frac{\sqrt{CL}}{5\times10^8}$$

$$N=\frac{5{,}000{,}000}{\sqrt{CL}}$$

T = time in seconds.
N = number of oscillations per second.

As a matter of practice, five to ten times the time constant, as found by the formula, was necessary for the full charge of the condenser.

The sparking distance between spheres of 2.6 centimeters in diameter had been investigated, and was shown on the diagram, Fig. 5. The line was almost straight, and, as a matter of convenience for memory, it might be said that a pressure of 3,000 volts was required per millimeter of spark-gap. This figure, however, was different when the gap was surrounded by gases other than atmospheric air, and also when the

Fig. 1. Mercury Turbine Break.

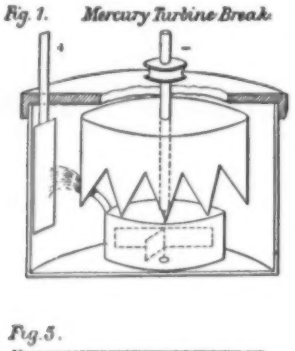


Fig. 2. Caldwell Break.

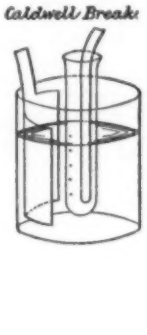


Fig. 3. Campbell-Swinton Break.

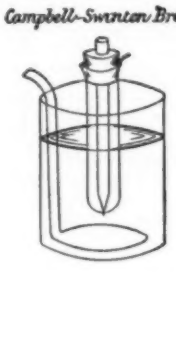
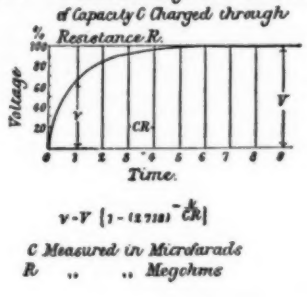


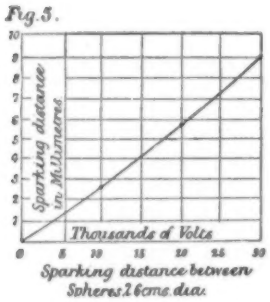
Fig. 4. Terminal Voltage of a Condenser of Capacity C Charged through Resistance R.



$$v = V\left[1-(2.718)^{-\frac{t}{CR}}\right]$$

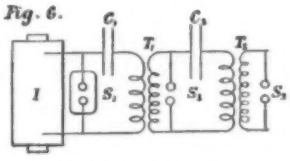
C Measured in Microfarads
R " " Megohms

Fig. 5.



Sparking distance between Spheres 2.6 cms. dia.

Fig. 6.



Multiple Oscillation Transformation

Fig. 7

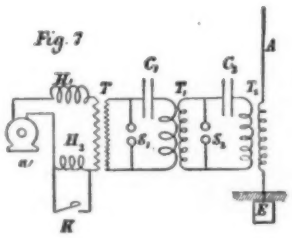


Fig 8.

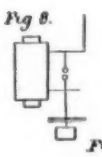


Fig. 9.

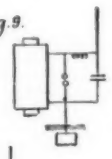
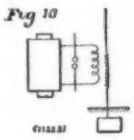


Fig 10



pressure of the air was varied. He then showed that by surrounding a spark-gap with air to the pressure of 50 pounds to 60 pounds per square inch, the air did not give way until the electric pressure had risen to a much higher limit than if the air were at atmospheric pressure. The apparatus he used to demonstrate this to the audience is illustrated in Fig. 6. In this I is a coil, C_1 a condenser, T_1 a transformer, S_2 a second spark-gap, and so on. When a spark occurred at S_1, oscillations were set up in the secondary of the transformer T_1, and sparks occurred at S_2, provided the balls were near enough together. It was possible, however, to place them so far apart that no spark took place under these circumstances. Then, by compressing the air around S_1, the electro-motive force produced by the coil I rose to a much higher figure before it broke down the air, and consequently a much greater inductive effect was produced in the transformer T_1, which showed itself by sparks at the gap S_2. It was thus demonstrated to the audience that as the atmospheric pressure rose round S_1, the electric pressure in the secondary circuit rose too. According to Prof. Fessenden, more radiation, the lecturer said, was given off from the aerial wire when there was an air pressure of 80 pounds per square inch in the gap than at other times. This was, no doubt, because of the greater suddenness with which the dielectric gave way, and allowed the spark to pass. Electric pressure was only generated in the secondary coil, and only radiated from the aerial when the primary current was being accelerated, and not when it was flowing uniformly; hence the value of a sudden break. The suddenness of the break was three and a half times as great when the pressure was 80 pounds per square inch as it was when it was 50 pounds.

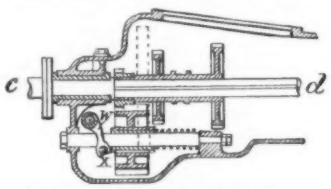
For getting the power necessary for aerial wires, an induction coil was inadequate. Such a coil as he had there could only be rated at one-tenth of a horse power, and its efficiency was not more than from 50 to 60 per cent. Hence recourse must be had to alternate-current transformers, which, again, introduced difficulties of their own. They had much lower resistances in the secondary, with the result that they were very apt to set up alternate-current arcs between the balls of the spark-gap. He had there a transformer encased in oil, which raised the voltage, which he took from the mains in the building, from 100 to 10,000. Across the terminals of this transformer was a spark-gap. This coil also charged a pair of Leyden jars, which fed a second spark-gap, enabling the audience to understand what was occurring at the first. The first gap was fitted up with a pipe, through which air could be forced to blow out the arc. As long as the arc persisted there was practically no charge in the jars, because the arc formed a constant conductor between the two balls, short-circuiting the terminals of the coil, but by blowing into the gap the arc was extinguished, and only the sparks left; under those conditions the jars were charged, and sparked freely across their gap. This was shown to the audience by the arc being first blown out, and then allowed to establish itself. Prof. Fleming said that he had had great difficulty to demonstrate to the United States Patent Office authorities that it was possible to blow out the arc and leave the sparks.

Dr. Fleming then threw upon the screen the diagram of a transformer arrangement designed by himself especially for the production of powerful electrical waves, shown in Fig. 7. In this a is an alternate-current generator—in this case the supply generator which was lighting the building—H_1 and H_2 are inductances, the lower of which can be short-circuited by the key K; T was a transformer, S_1 a spark-gap, C_1 a condenser, T_1 a second transformer, and T_2 a third. When the inductances H_1 and H_2 were in circuit, they choked the current so far that there was not sufficient electromotive force set up in the secondary of the transformer T to show at the spark-gap S_1; but when the inductance H_1 was short-circuited by the key K, then the sparks showed themselves. In this arrangement the inductances acted as throttle valves, and reduced the current in the primary circuit, and the key could be used as a sending key for signals.

Dr. Fleming then referred to the Cooper-Hewitt form of spark-gap, which had just been brought out in America. This is a variation of the mercury lamp. A glass globe has two short depending tubes filled with mercury, and the globe itself is exhausted. When the pressure from an alternate-current machine is connected to such an apparatus, it attains a very considerable amount before the current flows from terminal to terminal through the vapor of mercury with which the globe is filled. Once the circuit is established, the current persists, although the pressure may decrease very much. For instance, it may require 15,000 volts to establish the circuit, but when this is done the current will continue until the pressure has fallen to 20 to 30 volts. The distinguishing feature of this apparatus was, he said, the extreme suddenness of the make and break, which took place practically instantaneously.

The lecturer then turned his attention to energy-storing and voltage-raising devices. He said the most familiar of these were Leyden jars, but they suffered from the disadvantage that they were bulky and fragile. He had made a condenser in which the dielectric was micanite, and he showed a small box which had a storage capacity of six microfarads. It was remarkable how large a bulk of dielectric was necessary for the storage of electrical energy, as compared with the bulk of material for the storage of mechanical energy. One cubic foot of air would store 1 foot-pound of electric energy, but if 2 cubic feet of air were compressed into 1 cubic foot they would hold 1,440 foot-pounds of mechanical energy. Glass would only carry one-fortieth to one-fiftieth of a foot-pound per cubic foot, and this was a characteristic which it was impossible to get round. Micanite had a capacity of two to three times this, on account of its greater strength.

They had now, said the lecturer, considered the action of devices for electric telegraphy; they had to make the pressure, store it up, to release it at the spark-gap, and to cause the oscillations in the aerial. The defect of Marconi's simple form of aerial wire (see Fig. 12 *ante*) was the very small amount of energy which it would store up; a wire 100 feet long had a capacity of only 1-5000 of a microfarad, which was about one-tenth that of an ordinary Leyden jar. Yet this simple contrivance would signal satisfactorily over a radius of 100 miles; its fault was that it produced an impulse rather than a train of waves; it had not sufficient stored energy to send out wave after wave. An improvement upon this was the Marconi tuned aerial (see Fig. 35 *ante*), in which a coil was used to charge a condenser, which was discharged through a spark-gap and an oscillation transformer, the induced secondary oscillations being used in the aerial. This arrangement would give 20 or 30 oscillations, and so throw off a train of waves. It was important, however, that the time constant of both the circuits should be tuned, so that they were in unison. Its construction should be carried further, as shown in Fig. 7 where there are three successive transformations, enabling a spark-gap of 5 or 6 centimeters to be employed in the last circuit at S_2. A third method—intermediate between the above two—was introduced by Prof. Braun, and was shown in Fig. 29 *ante*. In this the oscillation transformer was dispensed with, and the aerial wire was connected to one pole of the condenser, the other being earthed. With this construction it was not possible to get such a store of energy in connection with the aerial. All the different forms of charging devices could be reduced to three



DETAIL OF REVERSE.

types, shown in Figs. 8, 9, and 10, of which the first and the last were due to Marconi, and the middle one to Braun. Dr. Fleming then quickly described the Slaby-Arco multiplier transmitter, the Slaby transmitter, the Allgemeine Elektricitäts Gesellschaft transmitter (Fig. 33, page 193 of Traction and Transmission for March), and the Lodge-Muirhead transmitter, pointing out in each case to which of the three typical forms they were related.

The last portion of the lecture dealt with Marconi's law of the distances to which signals could be sent. The law is as follows:

Marconi's law is: "With any given transmitter and receiver, if D is the distance in meters at which signals can be received on 'aerials' H meters high, then

$$D = CH^2,$$

where C is a coefficient varying from 30 to 1,000, according to the nature of the receiver and transmitter."

The proof is as follows: The wave energy varies as $\frac{1}{D^2}$ when H is constant. When D is constant the energy received varies as the square of the electromotive force in the receiving aerial, and therefore varies as H^2. Hence, when both vary together $\frac{H^2}{D}$ must be a constant determined by the nature of the receiver and transmitter.

The fact that the distance to which signals can be transmitted varies as the square of the height of the aerial had led some people to predict that it would never be possible to signal across the Atlantic, except by the aid of an aerial of some 2,000 feet in height. The law was perfectly true, but it depended upon the delicacy of the receiver; and although a height of 150 feet was needed at the South Foreland, yet in consequence of improvements in the other apparatus, aerials of a height of 200 feet had served for messages across the Atlantic. At the close of the lecture Dr. Fleming repeated the experiment of showing visually the form of a wave of electric pressure upon the aerial. He did that because Mr. Marconi and Lord Kelvin formed part of the audience, but had not been present at the previous lecture, and they desired to see the experiment. It was received with very great applause.

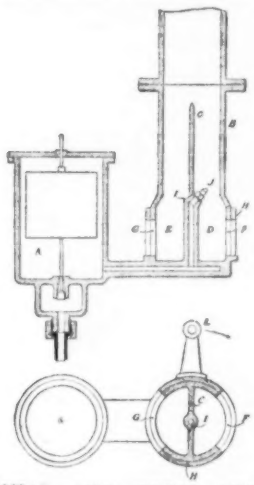
[Continued from SUPPLEMENT No. 1435, page 22996.]

SOME DETAILS OF THE PARIS-MADRID RACING AUTOMOBILES.

Specially Prepared by the PARIS CORRESPONDENT of the SCIENTIFIC AMERICAN.

II. THE MORS AUTOMOBILE.

AMONG the new machines which deserve attention is the improved 1903 Mors automobile. The motor, of the vertical type, placed on the front end of the chassis, has four cylinders mounted on a long crank-case. The water circulation takes place between the exterior



LONGITUDINAL AND CROSS SECTIONS OF MORS CARBURETER.

of the cylinder and an outer jacket of aluminium. This construction allows the cylinder to be turned both inside and out, and it can thus be reduced to the exact thickness required, giving a uniform cooling. One peculiarity of the motor is that the inlet valves are operated mechanically instead of automatically, as usual. For this purpose a second cam-shaft is placed parallel to the one which operates the exhaust valves. In consequence, each opening and closing of the inlet valve is produced exactly at the proper moment, doing away with the irregularities which may occur owing to the difference in tension of the valve spring. The governor keeps the motor at constant speed by throttling its supply of gas. The balls of the governor operate a fork on a sliding collar, and the latter, by means of a lever, works a circular throttle valve provided with a number of holes, which is placed in the pipe leading to each inlet valve. The governor may be blocked by a special device which permits the throttle valve to remain fully open. This device, called the "accelerator," is operated by a pedal. Besides, the position of the throttle valve, outside of the usual governor action, may be modified at will by the driver. For this purpose, the shaft which operates the lever of this valve is arranged so as to be worked by a handle, which is mounted on the steering post and moves over a sector. This "moderator," as it is called, acts through a spring which holds it in place and which allows the "accelerator" pedal to be worked momentarily, for instance, in mounting a slight grade, without changing the position

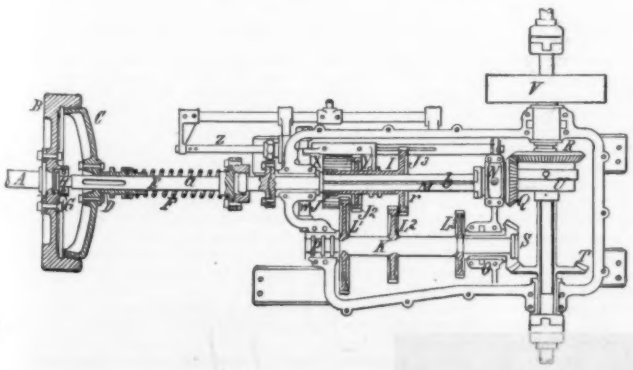
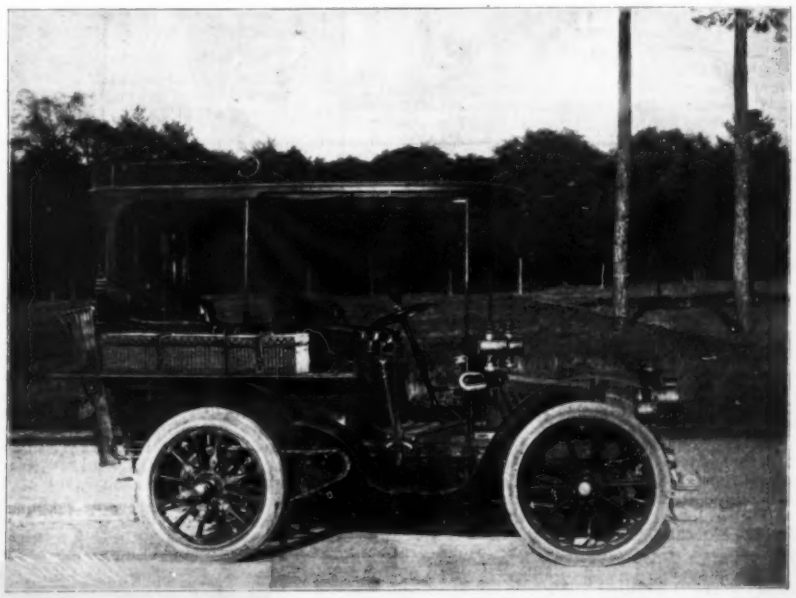


DIAGRAM OF CHANGE-SPEED GEAR.



THE 1903 MORS TOURING CAR.

of the moderator lever upon the sector. When the pedal is released, the whole is restored to the original position by the spring.

The various parts of the mechanism are arranged on the chassis in the usual manner. From the main friction clutch in the flywheel, a short piece of shafting leads to a large box containing the speed-changing gears and differential shaft. The latter projects out of the box on each side, carrying the sprocket wheels, which drive the rear wheels of the vehicle by chains. The change speed gear has been carefully designed so as to be as simple and efficient as possible. It gives a direct drive of the differential by the motor on the high speed, without using intermediate gears. The driving shaft, *M*, which is connected with the motor through the friction clutch seen on the left, carries a traveling gear set, *I*, formed by a sliding collar on which are mounted the main gears, J_1, J_2, J_3. The lower shaft, *K*, carries the secondary gears, L_1, L_2, L_3, and, to the right, a bevel gear, *S*, which meshes with the gear, *T*, mounted on the shaft of the differential, *U*. By engaging each one of the gear sets, $J_1 L_1$, $J_2 L_2$, $J_3 L_3$, the first three speeds are obtained. For the high speed, the collar of the sliding set, *I*, carries a jaw clutch on its right end, *r*, which when the gear set is slid to the right as far as possible, interlocks with its other half attached to the bevel gear, *Q*. The latter meshes with the bevel gear *R*, mounted on the differential. The maximum, or fourth speed, is thus obtained through the jaw clutch, and the motor drives the differential directly. This method of direct driving on the high speed, without the use of intermediate gears, is a great advantage, and is being used in most of the leading types of automobiles.

The stop and reverse are obtained as follows: When the lever is moved to the rear, from the slow speed notch, the gear J_1 of the sliding set moves off L_1 and comes in mesh with a small pinion, *X*, seen in the upper section. This is the stop position. When the lever is moved further to the rear, the tail of the shifting-fork, *Y*, pushes a small lever mounted on the lower fork, *W*. The latter, turning about its axis, pushes the pinion *X* toward the right and brings it in mesh with the lower pinion, L_3, of the slow speed. The lower shaft, *K*, is thus operated by the upper gear through the pinion *X*, and turns in the opposite direction, giving the reverse.

The motor is connected to the change gear box through a friction clutch with internal reactions, that is, there is no longitudinal thrust transmitted to the motor or the gearing. The motor shaft, *A*, carries a flywheel, *B*, in which is lodged the aluminium cone of the clutch, *C*. The latter is bolted to a collar, *D*, which slides upon the driving shaft, *E*. At the right-hand end of shaft *A* is a socket, *H*, in which is mounted a ball bearing, *G*, the latter being also fixed to the flywheel. The spring which serves to keep the friction clutch in place, bears at one end against a washer on the driving shaft and on the other against the cone of the friction clutch. By this disposition the thrust is taken up and the system well balanced. Although the chassis is made as rigid as possible, it is of advantage to provide for the case of an accidental deformation, which might prevent the shaft from turning. The driving shaft, *E*, is connected with the rear shaft by a joint of special form, which allows it to work at an angle. On the shaft is mounted a square socket in which is lodged a square piece Σ carried upon the shaft, *M*, of the gear-box. The square piece carries cylindrical faces, which form an articulation, and allow of a displacement of one shaft with respect to the other.

The system of carburetion also deserves special mention. Owing to the different improvements which have been made upon the motors, especially that of the mechanical operation of the inlet valves, the working régime has been considerably changed. While formerly the normal speed of the motor varied between 1,000 and 1,200 revolutions per minute, and its slow speed was about 600 revolutions, at present it is required to work at only 300 revolutions at the slow speed. This decrease of speed has been made possible by the use of the mechanically operated inlet valves. The difference of speed involves differences in the carburetion, and the type of carbureter which was formerly employed, although excellent for the usual speeds, is not adapted for the slow speeds which are now possible. The new Mors carbureter is designed to overcome the difficulties of carburetion at slow speed by furnishing a mixture of gas and air which is always capable of giving a maximum explosive effect with a minimum quantity of gasoline. The usual float-feed reservoir is seen on the left, feeding the gasoline at constant level into the second cylindrical chamber, *B*. The latter is divided into two parts by a partition, *C*, forming two chambers, *D* and *E*. These connect with the air through the openings *F* and *G*. These openings are closed by the revolving sleeve, *H* (see plan view), which is turned about the cylinder by the lever, *L*, so that both the air passages are opened or closed at the same time. The gasoline, arriving from the float chamber, rises in the column, *I*, and is sprayed through the nozzle, *J*, by the suction of the motor. During the aspiration of the motor, the air enters at *F* and also at *G*. In the chamber, *D*, it meets the gasoline spray, forming the carbureted mixture. In the upper part of the cylinder the carbureted air mixes with the pure air coming from the chamber, *E*. It is only necessary to give to the openings *F* and *G*, which are more or less uncovered by the collar, *H*, a profile such that the quantities of air entering the two chambers are always in the right proportion for forming a perfect mixture with the gasoline. The valve-collar, *H*, is worked directly by the governor of the motor, and is thus all that is required for the proper supply of air.

The Mors machines are also fitted with "honeycomb" radiators, formed of a great number of short copper tubes around which the water circulates. The radiator is mounted in front of the motor, and back of it is a fan driven by a pulley, for giving a good draught when the vehicle runs at slow speed. The use of this radiator, owing to its more effective cooling, allows the water supply to be diminished. It is used on the Mors racers heretofore illustrated, as well as on the touring car shown.

AUTOMATIC FOCUSING ENLARGING APPARATUS.

THE greatest difficulty to contend with in the making of enlarged prints on bromide or velox paper from small negatives is the focusing. While reduction tends to sharpen a print from a negative that may be slightly out of focus, the process of enlargement has the opposite effect, and no matter how sharp the negative may be, unless the image is critically focused and a very small stop used, the print will be disappointing. While it is possible to focus with comfort by using the full aperture of the lens and stopping down for the exposure, it is still uncertain whether the print will be sharp, for it occasionally happens in some lenses the focal point is altered by the substitution of the smaller stop. The camera illustrated, designed by Mr. H.

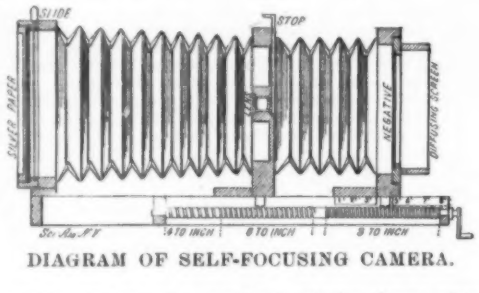
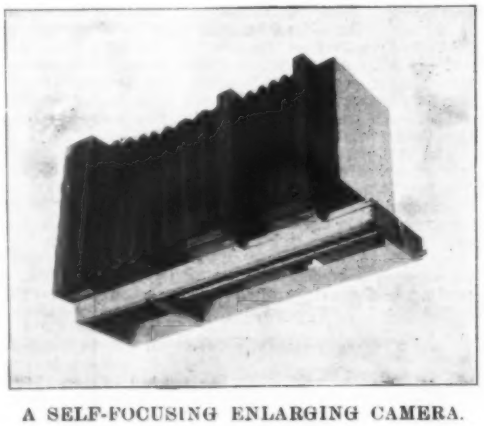


DIAGRAM OF SELF-FOCUSING CAMERA.

Stender, consists of a combined printing frame plate holder in which the sensitive paper is placed upon a sheet of clean glass; a light-tight back is then clamped down and holds the paper perfectly flat. The holder is inserted at one end of the camera, and the slide drawn when ready to expose. At the other end of the camera, kits are provided for receiving various sizes of negatives, over which is placed a framework bearing tissue paper for evenly diffusing the light. The partition in the center is provided with a lens and a simple form of shutter. As the lens has only one working diaphragm, and this a small one, it is of course difficult to focus the image except in direct sunlight. At the same time the fixed diaphragm has its advantage in that it simplifies the calculation of the exposure after a few trials. The principal feature of the camera, however, is that no focusing is necessary. The lens and negative supports engage with an ingenious combination screw shaft, provided with differentiating screw threads, mathematically cut, so that by turning the handle of the screw shaft at one end the negative travels over a scale which shows the extent of magnification and the lens is moved at a varying rate of speed by a coarser screw thread on the same shaft either forward or backward, always maintaining on the focusing screen or sensitive paper the correct focus for any size wanted. It will thus be seen that it is only necessary to load the holder with sensitive paper or plate in the



A SELF-FOCUSING ENLARGING CAMERA.

darkroom, insert it in the camera in daylight, turn the handle to the size desired, and expose at a saving of time and gain in definition and quality of work.

FICTITIOUS WINES: SOME INTERESTING RECIPES.

WE believe on the whole that the great bulk of the cheap wines sold to the British public by respectable merchants is genuine, in so far as that they are real fermented grape juice. This is, perhaps, more particularly so in regard to Bordeaux wines, though, doubtless, there are genuine light red wines imported as French wines which, however, have not been produced in France. Resent this comparatively trifling form of fraud as we may, it is obviously not so wicked as having a wine thrust upon us which is not fermented juice at all. A short time ago a person somewhere on the banks of the Rhine was caught compounding a fluid which he bottled and described as "Niersteiner," which of course implied that it was the wholesome wine produced in a certain district famous for its light Rhine wine. As a matter of fact, the fermented juice of the grape proved to be the smallest item in the formula, the rest being made up of alcohol, water, and certain flavoring materials. In this country also there is no doubt that to a certain extent—but we think a limited extent—fictitious wine is made. Thus, in some evidence given before the Departmental Committee on Food Preservatives four years ago it was stated that somewhere on the banks of the Thames a preparation was made which was sold as "St. Julien." As there was no duty paid on this stuff it is not surprising that its price was not more than 6½d. a bottle and we dare say that that figure left a fairly respectable margin of profit to the manufacturer. Possibly this "wine" brought a much higher price when ultimately sold by the retailer to an individual customer. It would be interesting to discover the true composition of the claret commonly labeled "St. Julien" which is to be found at most public houses or country inns, however remote they may be. As a rule there is nothing but the description "St. Julien" or perhaps "Medoc" on the label and there is certainly no evidence of *bona fides* on the cork. In this connection we have recently come across some interesting recipes for making wines which are calculated to throw some light on the "wine" which is now and again met with. To make Bordeaux wine, for example, "it is best to use a light Hungarian red wine. Mix with 50 gallons one pint of kino, two to three ounces of sulphate of iron, dissolved in one quart of boiling water, and one wine-glassful of extract of orris root and a like quantity of raspberry extract." We may parenthetically remark that we have occasionally tasted cheap clarets having a flavor resembling that of orris root. For making Burgundy it is enjoined to "mix in a barrel 100 parts of white wine, ten of the juice of black cherries, six of crushed large raisins, six of pulverized cinnamon, half of pulverized crude tartar, and 50 of must concentrated by evaporation." The following formulas are also suggested: "Champagne liqueur. Boil eight and three-quarters pounds of the finest loaf sugar with one gallon of water, add gradually while the water is boiling half gallon of alcohol of 90 per cent and then filter the mixture." "The above liqueur is added to all the following compounds." (We reproduce them literally to show the disgraceful use made of the names of certain well-known champagne firms.) "Chandon et Moet (Green Seal). Mix the above liqueur with seven and a half gallons of white wine and one quart of Cognac." "Louis Röderer (Green and Bronze Seal). Mix the champagne liqueur with seven and a half gallons of white wine, one bottle of Cognac, and four drops of sulphuric ether dissolved in Cognac." "Heidsieck et Cie. (Sealed with Tin-foil). Mix the champagne liqueur with seven and a half gallons of white wine and three quarters of a pint of Cognac." The next one is very interesting. "Lemberg Geldermann et Deitz (Sealed with Tin-foil). Mix double the quantity of champagne liqueur with seven and a half gallons of white wine and three-quarters of a pint of Cognac in which two roots of celery carefully cleansed have been previously digested for four hours." Similar formula for other brands are given and directions are appended for making Madeira, Malaga, and port. In one of these (Malaga) "essence de Goudron" is employed. The champagne preparations "are corked with champagne corks and laid on their sides with their mouths sloping downward. They are recorked the next day with the corking machine. The corks before using them must be laid in hot water, and before placing them in the machine moistened with sugar syrup, and as soon as driven into the bottles tied with cord and finally wired." Anything more brazen than this we can hardly imagine.—Lancet.

THE IRON PILLAR OF DELHI.

AN illustration of the famous iron pillar of Delhi, India, is given in a recent number of Cassier's Magazine, together with the following particulars of it:

The pillar is a solid shaft of wrought iron, 16 inches in diameter, and of a length that is variously reported. The total height above ground is 22 feet, including a capital of 3½ feet. Major G. A. Cunningham, R.E., C.S.I., director-general of the Archæological Survey of India, reported in 1863 that the total length of the pillar is upward of 48 feet, and possibly 60 feet.

The lower diameter is 16.4 inches and the upper diameter 13.5 inches. The pillar contains about 80 cubic feet of metal, and weighs about 17 tons. The metal was for a long time reputed to be bronze, owing probably to a curious yellowish shade on the upper part. A sample from near the base was analyzed by Dr. Murray Thompson and found to be pure malleable iron of 7.66 specific gravity. The metal is, of course, charcoal iron, made directly from the ore in small billets; but how it was welded up no one can tell, as no record exists of any early method of dealing with great masses of wrought iron.

An inscription, roughly cut or punched upon the column, states that Raja Dhara subdued a people in the Surdhu, named Vahlikos, and obtained with his own arm an undivided sovereignty on the earth for a long period. The date of the inscription has been referred to the third or fourth century after Christ; but on this authorities are at variance, as the style of writing is supposed by some to belong to a later period.

According to tradition, the Iron Pillar was erected by Bilan Deo, the founder of the Tomara dynasty, who was assured by a learned Brahmin that, as a part of the pillar had been driven so deep into the ground that it rested on the head of Vasuki, King of Serpents, who supports the earth, it was now immovable, and that dominion would remain in his family as long as the pillar stood. The Raja, doubting the truth of the Brahmin's statement, ordered the pillar to be dug up, when the foot was found to be wet with the blood of the serpent king. The pillar was again raised, but owing to the Raja's incredulity, no means could be found to fix it firmly, and it remained loose (dhila) in the ground, and this is said to have been the origin of the name of the ancient city of Delhi.

MACARONI WHEAT IN THE WEST.

MACARONI wheat seed was imported from Europe in 1901-1902. Nebraska and South and North Dakota this year have succeeded in producing wheat from this seed of excellent quality. The following facts have been proved by tests made in South Dakota:

1. The yield of macaroni wheat is from 60 to 120 per cent greater than that of ordinary blue stem and Fife wheats.

2. The quality of American-grown macaroni wheat is such that its products can be made of fully as high quality as those of the imported variety.

3. Already there is a greater demand from manufacturers than can be supplied by the growers of macaroni wheat.

4. Bread, more nutritious, and by many considered more palatable than ordinary bread, can be made from macaroni wheat.

The following results by the acre obtained from macaroni wheat as compared with the ordinary variety

in Edmunds County, S. D., a typical wheat region, explain the desire of the farmer of the grain belt to include macaroni wheat in his list of crops:

Thirty bushels macaroni wheat, at 75 cents a bushel, $22.50.

Twelve bushels ordinary wheat, at 70 cents a bushel, $8.40.

Macaroni wheat has been known in this country for thirty-five years, but not in its pure form until recently. The old variety is known as goose wheat, and was grown for years without any effort to keep it pure. This is of little more value to the manufacturer than the common bread wheat.

TRADE NOTES AND RECIPES.

Stamping Liquids and Powders.—Dissolve 1 drachm each of rosin and copal in 4 fluid ounces of benzine and with a little of this liquid triturate ½ drachm of Prussian blue and finally mix thoroughly with the remainder.

Here is another, somewhat of the nature of an oil paint. Zinc oxide is to be ground in oil and then thinned with lard oil to the consistency of cream. If desired colored, Prussian blue, also ground in oil, may be admixed with it. Such a paint is to be applied through a stencil, preferably with the use of a spatula. If it is desired to remove this afterward from the fabric, benzine may be employed. This method, it seems to us, is hardly a satisfactory one, and doubtless the first is better.

Ultramarine, to which has been added a small proportion of powdered resin, is generally used for stamping embroidery patterns on white goods. The powder is dusted through the perforated pattern which is then covered with a paper and a hot iron passed over it to melt the resin and cause the powder to adhere to the cloth. The following are said to be excellent powders:

1. White.—One part each of resin, copal, damar, mastic, sandarac, borax and bronze powder, and two parts white lead.

2. Black.—Equal parts resin, damar, copal, sandarac, Prussian blue, ivory black and bronze powder.

3. Blue.—Equal parts resin, damar, copal, sandarac, Prussian blue, ultramarine and bronze powder.

In all these powders the gums are first to be thoroughly triturated and mixed by passing through a sieve, and the other ingredients carefully added. Other colors may be made by using chrome yellow, burnt or raw sienna, raw or burnt umber, Vandyke brown, etc. For stamping fabrics liable to be injured by heat, the stamping is done by moistening a suitable powder with alcohol and using it like a stencil ink.—Pharm. Era.

Cement Recipes.—

Lime Cement for Stone.—

Slaked lime	10
Chalk	15
White alumina (kaolin)	5

And water glass as much as necessary. Mix and use fresh.

Casein Cements; Universal Cement.—

Mix slaked lime.....10 with
Freshly precipitated caseine.....10 and

the necessary quantity of fresh natural white of egg to cause a thick paste to result. Caseine is known to be the cheesy substance separating on the surface of milk in the preparation of whey. The production by heating the milk with alum, citric acid, cream of tartar, etc., is pretty well known.

Caseine Cement for Porcelain.—

Mix caseine .....12 and
Soluble soda glass.....55
Mix freshly precipitated caseine.....10
Soluble soda glass.....30 and
Soluble potash glass.....20

Gutta-Percha Cement.—

Carbon disulphide	30
Gutta-percha	4
Caoutchouc	10
Fish glue	2

Dissolve in the vapor bath.

Mastic Cement for Glass.—

Caoutchouc	10
Mastic	110
Chloroform	300

Dissolve in the vapor bath.

Cement for Rubbers.—

1.

Soak and dissolve

Cut-up caoutchouc	10 in
Benzine	50

adding enough benzine until the cement is thickly liquid. For use, it should be warmed to 50 deg. C. (122 deg. F.).

2.

Mix equal parts of the following two solutions:

A.	Caoutchouc	10
	Chloroform	250
B.	Caoutchouc	10
	Pine resin	4
	Oil of turpentine	40

Cement for Chemical Apparatus.—Melt together:

Gutta-percha	20
Yellow wax	10
Shellac	30

Cement for Ivory.—Melt together equal parts of gutta-percha and ordinary pitch. The pieces to be united have to be warmed.—Drogistische Rundschau, Zuerich.

Casts of Leaves, Fruits, Insects, etc.—For the production of casts of leaves, fruits, insects, etc., very easily fusible alloys are required, which must contain cadmium to preserve the articles from injury. Such a one is Wood's metal, consisting of tin 2 parts, lead 4 parts, bismuth 7 to 8 parts, and cadmium 1 to 2 parts. Its fusing point lies between 66 and 72 deg. C. Another is Lipowitz's metal, consisting of tin 4 parts, lead 8 parts, bismuth 15 parts, and cadmium 3 parts. At 55 deg. C. it becomes soft, and 66 deg. C. perfectly liquid.—Neueste Erfindungen und Erfahrungen.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

German Inquiry for Furniture and Dry Goods.—Consul T. J. Albert, of Brunswick, reports that an inquiry has been made for the names and addresses of prominent firms in the United States engaged in the manufacture of small decorative furniture, for the purpose of introducing their products into Germany. Not only furniture manufactured from different kinds of wood is desired, but furniture made of bamboo and rattan. There is also an inquiry for the names of American firms manufacturing colored cotton goods, madras, etc. Catalogues and samples of such goods would be gladly received. A price list is inclosed, showing the different kinds of furniture wanted, together with the prices prevailing in Germany,* which will be a guide for firms who propose to make offers. American manufacturers can communicate with the consulate or directly with the firm of Carl Langerfeldt, Brunswick, Germany. The following is taken from the price list:

Description.	Price.	
	Marks.	
Folding furniture for verandas, balconies, gardens, and dwellings (light weight and solid construction), Pompeian red, green, and natural:		
Armchair	6.00	$1.43
Bench, 45.3 inches long	10.00	2.38
Table—		
39.3 by 23.6 inches	10.00	2.38
Round, 21.6 inches in diameter	6.00	1.43
Bent wood, reseda or red lacquered:		
Chair	3.75	.89
Armchair	5.50	1.31
Sofa	11.00	2 62
Table	8.50	2.02
Bent reed, natural:		
Chair	14.00	3 33
Armchair	21.00	5.00
Sofa	36.00	8.57
Table	17.50	4.17
Oak hall racks	30.00 to 45.00	8.57 to 10.71
Chests	38.00 to 80.00	9.04 to 19.04
Screens, bamboo:		
Three panels	13.00 to 17.00	3.09 to 4.04
Four panels	17.00 to 21.00	4.04 to 5.00
Pedestals of walnut or mahogany	6.75 to 16.50	1.61 to 3.92

European Sugar-Beet Cultivation.—Consul Walter Schumann writes from Mainz, May 13, 1903, as follows:

The following table, regarding European sugar-beet cultivation for the season of 1903 as compared with that of 1902, has been compiled and published by the International Sugar Statistical Association as the result of a general inquiry made between the dates of April 29 and May 9:

Country.	Factories.	Area under sugar-beet cultivation				Increase.	Decrease.
		1903.		1902.			
	No.	Hectares.	Acres.	Hectares.	Acres.	p. c.	p. c.
Germany	385	412,093	1,018,282	429,341	1,060,902	..	4
Austria-Hungary	215	300,610	757,653	304,000	751,184	0 8	...
France	230	224,200	553,998	238,100	588,345		5 8
Russia	277	584,873	1,395,891	597,372	1,476,106		5.5
Belgium	99	57,501	142,083	52,300	129,253	9 9	....
Holland	29	40,343	99,687	31,035	76,687	3	...
Sweden	17	28,734	70,997	24,118	59,596	19.1	....
Denmark	7	14,700	36,324	14,700	36,324	..	....

Announcement.—On July 1, 1903, the Bureau of Foreign Commerce of the Department of State, which has had charge of the publication and distribution of the Consular Reports, will be transferred to the Department of Commerce and Labor, in pursuance of provisions in the act of Congress approved February 14, 1903, creating that Department, and will be consolidated with the Bureau of Statistics, transferred from the Treasury to the new Department. Reports from consular officers on commercial and industrial subjects will hereafter be transmitted through the Department of State to the Department of Commerce and Labor, and the latter will publish and distribute them.

A new bureau, to be known as the Bureau of Trade Relations, will, under authority of section 11 of the act of February 14, 1903, be organized in the Department of State on the 1st of July, to formulate, for the instruction of consular officers, the requests of the Secretary of Commerce and Labor; to prepare from the reports of consular officers for transmission to the Secretary of Commerce and Labor such information as pertains to the work of the Department of Commerce and Labor; to transmit consular reports on special subjects, other than commercial, to various branches of the government service; and to compile information for the use of the Department of State in the consideration of questions arising in the conduct of official relations with foreign governments.

Requests for consular reports should hereafter be made to the Department of Commerce and Labor.

Phosphate Concession in Barbuda, West Indies.—Consul W. R. Estes sends from Antigua, June 1, 1903, copy of a notice of tender for a concession to mine phosphate in the island of Barbuda, issued by the colonial secretary. The consul adds:

Barbuda is a small island about 28 miles northwest of Antigua, and is reached by sailing vessel from this port. It is reported that rock on the island contains 50 to 80 per cent of phosphate, but the extent of the deposit is unknown.

The notice reads:

"Tenders will be received up to the 1st of October, 1903, at the office of the colonial secretary, Antigua, for a concession to mine phosphate of lime or of alumina in the island of Barbuda, subject to the following conditions:

"1. The tenderer shall state the royalty he is prepared to offer per ton of phosphate exported.

"2. The tenderer shall be allowed to cut firewood for the purposes of working this concession within the island at a royalty of 1s. (24.3 cents) per cord (measuring 8 by 4 by 4 feet), provided that such wood shall only be cut on areas indicated by the manager, and that no timber or brushwood having a value for other purposes than that of firewood shall be cut under this concession.

"3. The tenderer shall be allowed to have a site for a wharf and storage on the lagoon not exceeding 10 acres, at the yearly rent of 5s. ($1.21) an acre, provided that such site shall be beyond half a mile from the limekiln in front of the 'Great House.'

"4. The tenderer shall have power to lay tramways to facilitate mining operations, subject to the right of the government to prescribe the route to be followed and the precautions necessary as regards gates, fences, and crossings.

"5. The concession to be for the period of twenty-one years.

"6. Preference to be given to the tenderer offering the highest royalty, starting from 9d. (18 cents) per ton exported as the 'upset' price.

"7. The concession to be voidable at the option of the government if less than ten men are constantly employed thereon, or in case of any transfer of the concession, direct or indirect, wholly or in part, without the previous sanction of the government.

"8. The acceptance of tenders received shall be subject to the final approval of the secretary of state, and the government does not bind itself to accept the highest or any tender."

Quinine Auction in Batavia.—The fourth sale of quinine by public tenders for the year 1903 was held at this city on the 29th ultimo, and the following were the transactions of the day:

There were put up for sale 4,762.8 kilogrammes (10,500 pounds) of sulphate of quinine, Editio II., packed in lots of 11.34 kilogrammes (25 pounds), of which only 45.36 kilogrammes (100 pounds)—four lots—were disposed of at 20 florins ($8.04) per kilogramme (2.2 pounds). The other bids being below the price limit, the remaining quinine was withdrawn until the next sale.

The price realized—20 florins ($8.04)—is equal to the unit price of 0.0775 florin (3.12 cents) for the bark at the Amsterdam market.

The total shipments of quinine for the month of April are reported to have been 1,074,973 kilogrammes (2,369,885.4 pounds).

The next sale will be held on the 27th instant.—B. S. Rairden, Consul at Batavia.

Spanish Request for Brick-Making Machinery.—Under date of May 30, 1903, Consul-General Julius G. Lay, of Barcelona, informs the Department that he is in receipt of a letter from Mr. Agustin Palomar de la Torre, of Saragossa, which states that he has been appointed to establish the pottery industry in that city, and, having heard of the excellent quality of the machinery manufactured by American firms, he desires to learn the names and addresses of American manufacturers of machinery for making bricks, tiles, and other ceramics. The consul-general suggests that the inquirer be addressed direct, in Spanish or French, sending catalogues and quoting prices, if possible, c. i. f. Barcelona. Freight rates can be ascertained from Ceballos & Co., 80 Wall Street, New York, agents of the Spanish Transatlantic Company, the steamers of which leave New York for Barcelona about the first of every month.

Copper Production in Hungary.—Consul F. D. Chester sends the following from Budapest, May 15, 1903:

There were mined in Hungary, in 1901, 161,547.8 metric tons of copper, the value of which was 236,565.31 crowns (say $47,313.06). The quantity produced in the preceding calendar year was some 20 tons larger. Formerly, 80 per cent of the copper was mined by the government, but in the past year only 50 per cent was so mined. There are at present 16 copper-mining concerns in Hungary, of which two State and three private undertakings supplied the greater part of the metal.

German Sailcloth in South America.—Consul B. H. Warner, of Leipzig, May 26, 1903, says:

German sail and awning cloth manufacturers of this city are making strong efforts to secure South American trade. A prominent sail manufacturer has just informed me that he has succeeded in establishing regular traffic with South American countries, and that he hopes before long to do the same in Cuba.

Trade Request from Melbourne.—Under date of June 6, 1903, the Bureau of Foreign Commerce has received a request for samples of native American products suitable for the manufacture of varnish: Ten pounds' ($4.87) worth of waxes of all kinds, gums, wax berries, resins, natural dye woods and berries, and the like. No manufactured article will be accepted. These goods are to be sent to Melbourne, Australia. Directions for their delivery at New York may be obtained by addressing George Rogers, Son & Co., 22 Gt. St. Helens, London, England.

Transit Dues at Lourenço Marquez.—Consul W. S. Hollis reports from Lourenco Marquez, May 2, 1903, that customs transit duties at that port have been abolished.*

* See Advance Sheets No. 1665 (June 16, 1903).

* Filed for reference in the Bureau of Foreign Commerce.

INDEX TO ADVANCE SHEETS OF CONSULAR REPORTS.

No. 1678, June 22.—Trade in the Canary Islands—Drawbacks in Hungary.

No. 1679 June 23.—*Announcement—Proposed Public Works in Hungary—*Phosphate Concession in Barbuda, West Indies—*German Inquiry for Furniture and Dry Goods—Railroad in the Harz Mountains, Germany—*Alkali Discovery in Germany—*Trade Request from Melbourne.

No. 1680. June 24.—Coal Importations at Marseilles—Changes in Mexican Stamp Taxes—*Spanish Request for Brick-making Machinery—German Railway Supplies for Italy—Selling Eggs by Weight in Germany.

No. 1681. June 25.—*The Osaka Exhibition—Consular Invoices in Salvador.

No. 1682. June 26.—*Financial Crisis in Tientsin—Quinine Auction in Batavia.

No. 1683. June 27.—The Chemical Industry in Germany—Trade Notes from Colombia.

The Reports marked with an asterisk (*) will be published in the SCIENTIFIC AMERICAN SUPPLEMENT. The other Reports can be obtained by applying to the Bureau of Trade Relations, Department of Commerce and Labor, Washington, D. C. Since the number of Reports is limited, application for those which are desired should be made immediately.

SELECTED FORMULÆ.

Museum Preserving Fluid.—

Formaldehyde solution, 40 per cent	60 parts
Glycerine	120 parts
Alcohol	30 parts
Water	1,000 parts

Mix. Glycerine is necessary only when the specimen is to be kept soft. The fluid can be made perfectly colorless and as limpid as distilled water by filtering through animal charcoal. In dense, massive objects, such as liver, lungs, etc., incisions should be made to allow the liquid to penetrate to the interior. It is better to use more formaldehyde solution—90 to 100 parts—in preparing very dense objects.—Pharm. Era.

Patent Leather Varnish.—

Resin	1 ounce
Gum thus	1 ounce
Turpentine	1 ounce
Sandarac	2 ounces
Shellac	4 ounces
Methylated spirit	30 ounces
Lampblack	½ ounce

Dissolve the resins in the spirit and finally add the lampblack.—Pharm. Era.

Solvent for Celluloid.—Amyl acetate is generally recommended as the best solvent for celluloid. A formula for "celluloid varnish" follows:

Celluloid parings	1 ounce
Amyl acetate	20 ounces

More or less amyl acetate may be used according to the purpose for which the varnish is required. The formula as given has been recommended especially for making gold paint.—Pharm. Era.

Liquid Cement for Cycle Tires.—

Raw gutta-percha	16 ounces
Carbon bisulphde	72 ounces
Eau de cologne	2 2-3 ounces

This cement is also the subject of an English patent and is recommended for patching cycle and motor tires, insulating electric wires, etc.—Pharm. Era.

Diamalt as a Substitute for Milk in Bakeries.—Diamalt is a thick sirupy mass of pleasant, strong, somewhat sourish odor and sweetish taste. The preparation has been analyzed by Drs. Brahm and Buchwald. Its specific gravity is equal to 1.4826. The percentage of water fluctuates between 24 and 28 per cent, the amount of ash is 1.3 per cent. There are present: Lactic acid 0.718 to 1.51, nitrogenous matters 4.68 to 5.06 per cent, and constituents rich in nitrogen about 68 per cent. The latter consist principally of maltose. Dissolved in water it forms a greenish-yellow mixture. Turbidness is caused by starch grains, yeast cells, bacteria and a shapeless coagulum.—Pharmaceutische Centralhalle.

Purification of Drinking Water in the Field.—For the purification of drinking water in the field Vaillard and Georges recommend three kinds of compressed tablets. No. 1. Make 100 tablets of potassium iodide 10 grammes, potassium iodate 1.56 grammes, and a little methylene blue; likewise prepare (No. 2) 100 tablets of tartaric acid 10 grammes and a little fuchsine, and the same number of sodium thiosulphate 11.6 grammes (No. 3) For 1 liter of water one lozenge of each kind is sufficient. If the water is muddy, it should be subjected to a superficial filtration. Otherwise dissolve lozenges 1 and 2 in a little water and add the solution to the water to be purified. After 20 minutes add lozenge No. 3, which binds the free iodine.—Pharmaceutische Centralhalle.

Liquid Ichthyol Soap (Sapo Ichthyoli liquidus).—

Ammonium sulfoichthyolate	10
Distilled water	15
Hebra's soap spirit (a solution of potash soap 120 in 90 per cent spirit 60 and spirit of lavender 5)	75

Liquid Tar Soap (Sapo Picis liquidus).—

Wood tar	25
Hebra's soap spirit	75

—Pharmaceutische Zeitung, Berlin.

Birch Balsam.—

I.

Alcohol	30,000 grammes
Birch juice	3,000 grammes
Glycerine	1,000 grammes
Bergamot oil	90 grammes
Vanillin	10 grammes
Geranium oil	50 grammes
Water	14,000 grammes

II.

Alcohol	40,000 grammes
Birch oil	150 grammes
Bergamot oil	100 grammes
Lemon oil	50 grammes
Palmarosa oil	100 grammes
Glycerine	2,000 grammes
Borax	150 grammes
Water	20,000 grammes

—Seifensieder Zeitung.

Straw Hat Varnish.—

Shellac	4 ounces
Yellow resin	1 ounce
Methylated spirit	2 pints
Best spirit black	2 ounces

Dissolve the shellac and resin in the spirit and add the powdered black. Any soluble aniline dye may be used instead of the black.—Pharm. Era.

Cobalt Fly-Paper.—

Quassia chips	150 parts
Chloride of cobalt	10 parts
Tartar emetic	2 parts
Tincture of long pepper (1 to 4)	80 parts
Water	400 parts

Boil the quassia in the water until the liquid is reduced one-half, strain, add the other ingredients, saturate common absorbent paper with the solution and dry. The paper is used in the ordinary way.—Pharm. Era.

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